FEASIBILITY STUDY WORK PLAN

Lower Passaic River Study Area
Remedial Investigation/Feasibility Study

Prepared for
Lower Passaic River Cooperating Parties Group
New Jersey

Prepared by
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February 19, 2015

616091

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ACRONYMS AND ABBREVIATIONS

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
2007 Settlement Agreement	Administrative Settlement Agreement and Order on Consent
AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirement
BERA	baseline ecological risk assessment
BHHRA	baseline human health risk assessment
CAD	confined aquatic disposal
CAG	community advisory group
CDF	confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
COC	contaminant of concern
COPC	contaminant of potential concern
COPEC	contaminant of potential ecological concern
CPG	Lower Passaic River Cooperating Parties Group
CSM	conceptual site model
CSO	combined sewer overflow
cy	cubic yard
EPA	U.S. Environmental Protection Agency
EPA Sediment Guidance	Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA 2005)
FFS	focused feasibility study
FS	feasibility study
FSP	field sampling plan
FSWP	feasibility study work plan
GRA	general response action

LPR	Lower Passaic River
LPRRP	Lower Passaic River Restoration Project
LPRSA	Lower Passaic River Study Area
LRC	low-resolution coring
MLW	mean low water
MNR	monitored natural recovery
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NGVD	National Geodetic Vertical Datum
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NOAA	National Oceanic and Atmospheric Administration
NRDA	natural resource damage assessment
NRRB	National Remedy Review Board
O&M	operations and maintenance
OCC	Occidental Chemical Corporation
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-*p*-dioxin
PCDF	polychlorinated dibenzofuran
PQL	practical quantitation limit
PRG	preliminary remediation goal
PRP	potentially responsible party
RAL	remedial action level
RAO	remedial action objective
RARC	risk analysis and risk characterization
RBTC	risk-based threshold concentration
RG	remediation goal
RI/FS	remedial investigation and feasibility study

RM	river mile
ROD	record of decision
SOW	statement of work
SSP	supplemental sampling program
SWAC	surface area-weighted average concentration
SWO	stormwater outfall
TBC	to be considered
TCRA	time-critical removal action
Tierra	Tierra Solutions, Inc.
TMDL	total maximum daily load
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound

1 INTRODUCTION

This feasibility study work plan (FSWP) has been prepared as part of the Lower Passaic River Study Area (LPRSA) remedial investigation and feasibility study (RI/FS), which is being performed by the Lower Passaic River Cooperating Parties Group (CPG), in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and under the oversight of the U.S. Environmental Protection Agency (EPA).

The FSWP presents the scope and detailed procedures to conduct the feasibility study (FS) for the LPRSA, which encompasses the 17.4-mile tidally influenced portion of the Lower Passaic River (LPR) and its tributaries from Newark Bay upstream to Dundee Dam (Figure 1-1). The LPR is an integral part of the Greater Newark Bay complex, along with Newark Bay, Hackensack River, Arthur Kill, and Kill Van Kull.

The LPRSA is an operable unit of the Diamond Alkali Superfund Site. In May 2007, EPA entered into an Administrative Settlement Agreement and Order on Consent (2007 Settlement Agreement; USEPA 2007) with the CPG to complete the RI/FS for the LPRSA.[1] The RI/FS provides a comprehensive study of environmental conditions, human health and ecological risks, and remedial alternatives for the entire 17.4 miles of the LPRSA.

The initial draft FSWP was first submitted to EPA in August 2008. The CPG submitted a revised draft FSWP to EPA in March 2009 (AECOM 2009), in response to agency comments received in November 2008. EPA provided comments to the CPG on the 2009 revised draft FSWP on December 13, 2013. A third revision was submitted to EPA in August 2014. This revision to the draft FSWP addresses EPA's August 2014 comments on the Work Plan.

The FS process described in this FSWP will present and evaluate a range of cleanup approaches to address the entire 17.4 miles of the LPRSA. EPA has performed other remedial evaluations in the LPRSA, which are presented in the focused feasibility study (FFS), initially issued by EPA in 2007 (MPI 2007b) and updated in 2014 (LBG 2014). EPA's FFS, described further below, addresses only the lower 8.3 miles of the LPRSA and emphasizes bank-to-bank approaches to sediment cleanup.

[1] The CPG includes more than 60 cooperating members identified as potentially responsible parties (PRPs) for environmental response action in the LPRSA. Other parties who have been identified as potentially responsible are not members of the CPG.

1.1 REGULATORY SETTING

The RI/FS work required by the Settlement Agreement is being conducted under CERCLA, as implemented through the regulatory requirements of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR § 300.430). The FS process, and any potential response action selected based on the FS, must comply with CERCLA and be performed in a manner consistent with its associated guidance. The specific documents defining the conduct of the FS process on the LPR include:

- 2007 Settlement Agreement (USEPA 2007)
- Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988)
- Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites (USEPA 2002a)
- Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA 2005)
- A Guide for Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents (USEPA 1999)
- A Guide for Developing and Documenting Cost Estimates during the Feasibility Study (USEPA 2000)
- A Risk Management Strategy for PCB-Contaminated Sediments (NRC 2001).

1.1.1 The Diamond Alkali Superfund Site

The Diamond Alkali Superfund Site consists of three operable units, one of which is the LPRSA (Operable Unit 2 [OU2]). The other two operable units are the former Diamond Alkali pesticide manufacturing plant and surrounding properties at 80 and 120 Lister Avenue in Newark, New Jersey (OU1), the 17-mile LPRSA, and the Newark Bay Study Area (OU3). The upland properties within the Lister Avenue OU are on the south bank of the LPR at river mile (RM) 3.2 (Figure 1-2). Lister Avenue was left uncontrolled from approximately the late 1960s to mid-1980s, at which time the State and EPA became involved because elevated levels of dioxin contamination were found at the site. An interim remedy for Lister Avenue was implemented to prevent direct exposures to the contaminated soils and contaminated buildings and debris, prevent further migration of the contaminated groundwater, and prevent surface runoff of stormwater. The remedial actions for Lister Avenue included capping of contaminated soils and debris on site, constructing a slurry wall and flood wall, and pumping and treating of the contaminated groundwater. All construction activities were completed on June 2, 2004. The Newark Bay Study Area is a portion of the New York/New Jersey Harbor estuary and consists of Newark Bay and portions of the Hackensack River, the Arthur Kill, and the Kill Van Kull.

RI activities are ongoing in the Newark Bay Study Area. Remedial activities at Lister Avenue and in the Newark Bay Study Area are not governed by the 2007 Settlement Agreement between EPA and the CPG and are being carried out separately from the LPRSA RI/FS.

In addition to the 2007 Settlement Agreement providing for the completion of the LPRSA RI/FS, the following agreements have been reached to perform sediment removal actions under CERCLA in portions of the LPRSA:

- Under a Settlement Agreement executed on June 23, 2008, by and between EPA, Occidental Chemical Corporation (OCC) and Tierra Solutions, Inc. (Tierra), OCC agreed to fund and perform the removal and disposal of 200,000 cubic yards (cy) of LPR sediment located adjacent to Lister Avenue, part of the Diamond Alkali Superfund Site. The primary objective of the work was to remove a significant portion of the most concentrated inventory of dioxin-contaminated sediments, thereby removing source material that poses a potential risk to human health and the environment, and to minimize the possibility of migration of contaminants due to extreme weather events (USEPA 2008a, 2009). Sampling conducted in the Phase 1 removal area (2011 Lister Avenue Joint Defense Group Sediment Sampling) detected the highest concentrations of dioxin in the river. These data indicate that the deposits adjacent to Lister Avenue contain the highest mass of dioxin contamination in the river. These data, evaluated in conjunction with the CPG data sets, demonstrate that the mass of dioxin within the LPRSA decreases away from the Lister Avenue source area (Israelsson et al. 2013). On January 9, 2009, EPA, in consultation with the New Jersey Department of Environmental Protection (NJDEP), issued an Action Memorandum and selected the final plan for the Phase 1 non-time-critical removal action. In 2011, OCC (through Tierra Solutions) began removal of 40,000 cy of the most elevated dioxin-contaminated sediments from the LPR in a 2-acre area in the immediate vicinity of the Lister Avenue site (Figure 1-2). An additional planned removal of 160,000 cy of LPR sediments from an adjacent shoreline area on either side of the Phase 1 removal action (Phase 2) is currently unscheduled.
- Under a Settlement Agreement executed on June 18, 2012, by and between EPA and the CPG, the CPG agreed to fund and perform the removal and disposal of between 15,000 and 20,000 cy (top 2 ft) of LPR sediment within a mudflat at RM 10.9 (Figure 1-3). The objective of this work was to remove surficial sediments with elevated concentrations of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), polychlorinated biphenyls (PCBs), and other contaminants of potential concern (COPCs) and cap in place remaining sediments to reduce the potential for exposure to receptors and to prevent potential migration of contamination from the RM 10.9 removal area. The RM 10.9 removal action, which is being conducted under CERCLA authority as a time-critical removal action (TCRA), was initiated in July 2013. The removal of a final volume of 16,050 cy of sediments was completed on October 3, 2013, followed by capping, which was completed on May 29, 2014.

1.1.2 Lower Passaic River Restoration Project

The Lower Passaic River Restoration Project (LPRRP), congressionally authorized in 1999 under CERCLA and the Water Resources Development Act, is a remediation and ecosystem restoration initiative for the LPR watershed. The RI/FS for the LPRSA was identified in the 2007 Settlement Agreement as a component of the LPRRP. In addition to EPA, several other federal and state agencies—collectively designated under the Settlement Agreement as "Partner Agencies"—have been designated as LPRRP participants. These include the U.S. Army Corps of Engineers (USACE), the New Jersey Department of Transportation (NJDOT), the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (USFWS), and NJDEP.

In addition to the RI/FS, other studies of the LPR are occurring as part of the LPRRP. USACE is conducting studies that consider opportunities for ecological restoration, flood control, and navigational improvements. EPA (under the Clean Water Act and separate from the LPRSA RI/FS) is conducting total maximum daily load (TMDL) studies for improving water quality in the Passaic River and other water bodies in the New York/New Jersey Harbor complex. State and federal trustees for natural resources (NOAA, USFWS, and NJDEP) are also conducting a natural resource damage assessment (NRDA) under the LPRRP.

1.1.3 EPA Focused Feasibility Study

In April 2014, EPA issued a FFS to address sediments in the lower 8.3 miles of the river (FFS Study Area), which EPA identified as a major source of contamination to the rest of the river below Dundee Dam and to Newark Bay (LBG 2014).[2] EPA completed the 2014 FFS "…to evaluate taking action to address these sediments while the comprehensive study of the 17-mile Lower Passaic River is on-going" (USEPA 2014). The FFS evaluates four remedial alternatives:

FFS Alternative 1—No Action

FFS Alternative 2—Deep Dredging with Backfill: dredging of all fine-grained materials in the lower 8.3 miles, including restoration of the federal navigation channel from RM 0 to 8.3.

FFS Alternative 3—Capping with Dredging for Flooding and Navigation: dredging for placement of an engineered cap in the lower 8.3 miles, including partial restoration of the federal navigation channel in the lower 2.2 miles.

FFS Alternative 4—Focused Capping with Dredging for Flooding: dredging of portions of the lower 8.3 miles (adding up to 220 acres) to a depth of 2.5 ft, with placement of an engineered

[2] EPA issued a prior version of the FFS for the lower 8.3 miles in 2007 (MPI 2007b), which it then characterized as an evaluation of remedial alternatives that might be implemented as an early action for source control.

cap over the dredged portions. FFS Alternative 4 has no provisions for restoration of the navigation channel.

EPA issued a proposed plan concurrently with its release of the 2014 FFS, identifying Alternative 3 as the preferred alternative for the FFS Study Area. EPA has stated it expects to issue a ROD for the lower 8 miles in 2015.

1.2 The Feasibility Study Process

The purpose of an FS is to develop and evaluate a range of alternative methods for achieving the proposed remedial action objectives (RAOs) for the LPRSA CERCLA site. The FS process lays the groundwork for proposing and selecting a remedy that addresses site-related risks to human health and the environment, taking into account nine evaluation factors specified under the NCP (40 CFR § 300.430(e)(9)(iii)), including overall protection of human health and the environment; compliance with applicable or relevant and appropriate requirements (ARARs); long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; cost; state acceptance; and community acceptance.

The FS process follows several steps outlined in the RI/FS CERCLA guidance (USEPA 1988), as well as elements outlined in Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (hereinafter referred to as "EPA Sediment Guidance") (USEPA 2005).

1.2.1 Definitions for the Feasibility Study

Key terms that will be used in the FS are defined in this section, along with the appropriate regulatory citations, where applicable.

Applicable or relevant and appropriate requirements (ARARs) are promulgated federal and state standards, requirements, criteria or limitations that are determined to be "applicable" or "relevant and appropriate" to a CERCLA response action. Under Section 121(d) of CERCLA, an "applicable" requirement is a promulgated federal or state standard that specifically addresses a hazardous constituent, remedial action, location or other circumstance at the site. For a requirement to be applicable, its intended scope and authority must encompass the planned remedial actions and/or circumstances at the site. A "relevant and appropriate" requirement is a promulgated federal or state requirement that addresses problems or situations similar to those encountered at a site, even though the requirement is not legally applicable.

Background is defined by USEPA (2002b) as "[s]ubstances or locations that are not influenced by the release from a site and are usually described as naturally occurring or anthropogenic: (1) Naturally occurring substances are present in the environment in forms that have not been influenced by human activity, (2) Anthropogenic substances are natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA site in question)." USEPA (2002b) further identifies background as concentrations of contaminants in environmental media. Therefore, for the purposes of the FS, background will refer to concentrations of contaminants found in the surface water, sediment, and tissue collected from background locations.

Cleanup levels, or final **remediation goals (RGs),** are defined under CERCLA guidance as the concentration of a hazardous substance in an environmental medium determined to be protective of human health and the environment under specified exposure conditions (USEPA 1999). Cleanup levels/RGs represent concentrations of contaminants of concern (COCs) in environmental media and are required under CERCLA for each COC, receptor, and exposure pathway identified in the human health and ecological risk assessments. Final cleanup levels are prescribed in the record of decision (ROD).

The overall integration of RAOs, preliminary remediation goals (PRGs), and remedial action levels (RALs) will be further developed in the preparation of the FS, incorporating available data in an iterative process, culminating in the presentation of final cleanup levels in the ROD.

COPCs are identified in the baseline human health risk assessment (BHHRA) using a multistep screening process that is intended to distinguish between: (1) chemicals that pose negligible risks and can be eliminated from further evaluation, and (2) chemicals that warrant further evaluation of their potential to pose unacceptable risk to human receptors (i.e., COPCs). All COPCs identified as a result of the screening process are evaluated in the BHHRA to identify those COPCs that are significant contributors to site-related human health risks.

Contaminants of potential ecological concern (COPECs) are identified in the screening level ecological risk assessment based on a comparison of maximum chemical concentrations detected in applicable exposure media with conservative literature values or screening levels for each receptor group. All COPECs identified as a result of the screening process are evaluated further in the baseline ecological risk assessment (BERA) to identify those COPECs that are significant contributors to site-related ecological risks. (Note: when referring collectively to COPCs and COPECs elsewhere in this work plan, the term COPC is used.)

COCs are a defined as a subset of the COPCs and COPECs that are identified in the RI/FS as needing to be addressed by the response action. COCs will be identified in the baseline risk assessments and will be the focus of the remedial alternatives to be evaluated in the FS. The terms "contaminant of concern" and "chemical of concern" are synonymous under CERCLA (USEPA 1988, 2001, 2002b).

Practical quantitation limit (PQL) refers to the practical quantitation limit for a chemical concentration reported from a laboratory analysis and is generally equivalent in meaning to the terms quantitation limit and reporting limit. The NCP (40 CFR § 300.430(e)(2)(i)(A)(3)) allows that cleanup levels be modified based on "factors related to technical limitations such as detection/quantification limits for contaminants."

Point concentrations are chemical concentrations in sediments at a given sampling location. Point concentrations are typically applied to small exposure areas (e.g., benthic organisms with small home ranges). Point concentrations usually pertain to smaller-scale management areas for the protection of benthic communities.

PRGs specify the estimated endpoint concentrations or risk levels for each exposure pathway that are believed to provide adequate protection of human health and the environment, and comply with ARARs, based on available site information (USEPA 1991b,c, 1997). A PRG is a specific identification of a contaminant concentration or risk level in an environmental medium (e.g., sediment, water, or fish tissue) that is protective of human health and/or the environment under a given exposure scenario. Initially, PRGs may be defined using ARARs or generic cleanup levels, but they are often reevaluated during the RI/FS process as the CSM is refined and site-specific studies, including the BHHRA and BERA, and the characterization of background conditions, become available (USEPA 1999). Risk-based PRGs may be represented as a range of values corresponding to a risk level or range considered to be acceptable by EPA. Final cleanup levels are established in the ROD and may differ from the PRGs based on selection of different target risk levels and/or exposure scenarios than were used in the development of PRGs, taking into consideration factors and tradeoffs evaluated in the nine criteria analysis under the NCP (USEPA 1999). For the FS, PRGs will be expressed as tissue, sediment, and/or surface water concentrations for the risk drivers, and will be established considering risk-based threshold concentration (RBTCs), ARARs, background concentrations, and PQLs.

RAOs provide a general description of what the proposed remedial or response action is expected to accomplish to address the risks posed by the site (USEPA 1999, 2005). They are narrative statements of the medium-specific or area-specific goals for protecting human health and the environment. RAOs are used to help focus development and evaluation of remedial alternatives. RAOs are derived from the risk assessments and are based on the exposure pathways and receptors and the identified COCs. Narrative RAOs form the basis for establishing PRGs.

RALs are chemical-specific sediment concentrations that are used to delineate areas where active remedial measures (e.g., dredging or capping) will be undertaken under a given remedial alternative. RALs are not the same as PRGs or RGs, which define the ultimate risk-reduction or ARAR-based goals to be achieved by the remedial action, and which are not always expressed as sediment concentration goals. RALs may differ among various remedial alternatives, reflecting different tradeoffs among considerations of immediate risk reduction, longer-term recovery, remedy scale and implementability, and cost. RALs also may differ among different areas of a site, depending on the magnitude and type of risk to be addressed, land use, and the expected rate of future natural recovery.

RBTCs are concentrations of COCs in environmental media estimated to be protective of humans and ecological receptors, derived using risk levels (or ranges) considered by EPA to be acceptable using site-specific exposure scenarios other site-specific methods and assumptions for quantifying risk established in the BHHRA and BERA. As such, RBTCs provide a means to evaluate risk management efforts to reduce or eliminate pathways of exposure to COCs that result in estimated risks that are higher than levels considered acceptable by EPA. RBTCs are used, along with other site information, to set PRGs in the FS. RBTCs may be expressed as either point concentrations or surface area-weighted average concentrations (SWACs).

Risk drivers within this FS are defined as the COCs identified in the risk assessment that are driving the need for remedial action. Risk drivers are the chemicals that are primarily responsible for exceedances of the target cancer risk range of $1x10^{-4}$ to $1x10^{-6}$ or hazard indices greater than 1. EPA risk assessment policy states that one of the key goals of the risk assessment is to identify the chemicals and pathways that pose the majority of the site risk. Risk drivers are used in the FS to identify contaminant-specific PRGs and RALs that define the scope of remedial actions under each remedial alternative, and the target concentrations that the remedial action is intended to accomplish.

SWACs are similar to a simple arithmetic average of point concentrations over a defined area, except that each individual concentration value is weighted in proportion to the sediment area it represents, thereby minimizing the influence of spatially biased sampling. SWACs have been used at several other CERCLA contaminated sediment sites (e.g., Fox River [WDNR and USEPA 2002] and Lower Duwamish Waterway [EPA 2013b]) and may be used to evaluate reductions in sediment concentrations. The selected area over which a SWAC is applied is specific to the receptor being evaluated. For example, river-wide SWACs may be appropriate for estimating risks attributable to human consumption of fish or shellfish that range over wide areas. SWACs may also be calculated for smaller exposure areas for receptors with smaller home ranges.

Target areas are candidate areas that will be identified within the FS for active sediment remedial measures (e.g., dredging, capping, *in situ* treatment, and/or enhanced natural recovery [ENR]) under one or more of the remedial alternatives. Target areas, by definition, include mappable areas of the sediment bed that exceed RALs established for a given remedial alternative. A variety of mapping techniques is available to delineate the footprints of the target areas.

TBCs (to-be-considered information) are non-promulgated criteria, advisories, guidance, and proposed standards issued by federal or state governments. TBCs are not potential ARARs because they are neither promulgated nor enforceable although it may be necessary to consult

TBCs to interpret ARARs or to determine preliminary remediation goals when ARARs do not exist for particular contaminants or may not be sufficiently protective. Compliance with TBCs is not mandatory.

1.2.2 Feasibility Study Data Sets and Information Sources

Several elements of the RI/FS program will provide data and information to support the FS, including environmental characterization data collected and compiled in the RI and conceptual site model (CSM); the results of the baseline human health risk assessment and BERA; and the output of the hydrodynamic, sediment transport, contaminant fate and transport, and bioaccumulation models; and treatability studies.

The baseline data sets for the FS were collected during the LPRSA RI between 2005 and 2013 (Table 1-1). In addition to the RI data, some of the data collected by others and prior to the initiation of the LPRSA RI will be used to support FS evaluations (e.g., the low-resolution sediment cores collected by Tierra in 1995 between RM 1 and RM 6). A complete list of data used to support the LPRSA RI/FS will be provided in the RI report. Four major sediment sampling programs were performed as part of the RI, with samples collected at approximately 450 locations.

1. The 2008 Low-Resolution Coring (LRC) program cores were advanced to native material or refusal (AECOM 2011b)
2. 2009/2010 Benthic sediment grab program included collection of surficial (0- to 6-in.) grab samples (Windward 2011d)
3. 2012 LRC Supplemental Sampling Programs (SSP) cores were advanced to a depth of 2.5 ft (AECOM 2013b)
4. 2013 LRC SSP2 included a combination of surficial grabs and cores that were advanced to native material or refusal (AECOM [in prep.]-c).

All samples were analyzed for a full suite of COPCs (i.e., polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans [PCDDs/PCDFs], PCBs, pesticides, polycyclic aromatic hydrocarbons [PAHs], and metals) and physical parameters (grain size, total organic carbon, and percent moisture). Surficial samples were analyzed for volatile organic compounds (VOCs) and acid-volatile sulfide/simultaneously extracted metals, and the LRC samples were analyzed for radiochemical data (cesium-137 and lead-210). There are several additional sediment data sets that were not collected as part of the LPRSA RI, but that will support the FS evaluations. These data include the cores from the RM 10.9 investigation (2011/2012; low resolution cores analyzed for the suite of COPCs and high resolution cores analyzed for radiochemical parameters), the EPA empirical mass balance model sediment cores (2007), the five EPA high-resolution cores (2006), and the 99 Tierra low-resolution cores (1995) collected between RM 1 and 6, advanced to native material. The Lister Avenue Joint Defense Group sediment cores

(2011) can also be used in the LPRSA FS following a demonstration that the data meet EPA QA/QC and data usability standards which will be provided in the LPRSA RI report.

Ecological data, including tissue sampling, toxicity analyses, and avian and habitat surveys were collected as part of the RI to support the risk assessments. In addition to these data, older tissue data, collected by EPA and Tierra prior to the initiation of the RI, were used to characterize temporal changes in tissue concentration in the LPRSA.

A series of five bathymetry surveys was performed between 2007 and 2012 to support the RI; these surveys were performed using the same methodology and equipment each time (to the extent practicable) to provide a set of comparable data. Depth-difference maps were calculated from paired surveys; these data are used to assess changes in bathymetry greater than ± 0.3 m (AECOM 2010a). These data support contaminant mapping and sediment stability evaluations. The following historical bathymetry data were also used to support sediment stability and surface mapping evaluations:

- 1949 USACE post-dredging survey
- 1966 USACE conditions survey
- 1995 Tierra bathymetry survey.

The 1949 and 1966 data were digitized and georeferenced from available survey maps. The 1995 single-beam survey was performed in RM 1 to 7 by Tierra as part of the initial RI.

Paragraph 37.i of the AOC and Section F.5 of the statement of work (SOW) state that the FS is anticipated to include the identification of candidate remediation technologies for evaluation in a treatability study program, followed by the implementation and documentation of those treatability studies in a series of interim technical memoranda and other deliverables. In the time since the AOC was signed in 2007, several bench-scale tests, pilot tests, and removal actions have been undertaken to date by EPA and its Partner Agencies, the CPG and Tierra Solutions/Maxus/Occidental Chemical Corporation. These are documented as follows:

- Cement-Lock® Technology for Decontaminating Dredged Estuarine Sediments. Gas Technology Institute. November 2008
- Demonstration Testing and Full-scale Operation of the BioGenesis℠ Sediment Decontamination Process: Final Report. BioGenesis Washing BGW, LLC, Springfield, VA. December 2009
- Environmental Dredging Pilot Study Report—Lower Passaic River Restoration Project. Prepared for U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, New Jersey Department of Transportation. Louis Berger Group. July 2012

- River Mile 10.9 Removal Action—Sediment Washing Bench-scale Testing Report, Lower Passaic River Study Area—CERCLA Docket No.02-2012-2015. CH2M Hill, Inc. 2012
- Final Construction Report–Lower Passaic River Study Area–Phase 1 Removal Action, Tierra Solutions, Inc. March 2013
- River Mile 10.9 Removal Action, Final Design Report, Lower Passaic River Study Area. CH2M Hill, Inc. July 2013
- Focused Feasibility Study Report, Lower Eight Miles of the Lower Passaic River. Prepared for the U.S. Environmental Protection Agency Region 2 and U.S. Army Corps of Engineers Kansas City District. Louis Berger Group, April 2014.

A summary of the findings from these activities and their bearing on the development and evaluation of remedial alternatives for the LPRSA will be incorporated into the FS. No additional bench-scale tests or pilot studies are currently planned to complete the FS.

1.2.3 Feasibility Study Activities

Activities specific to preparing the FS will include:

- Summarizing the current site conditions by presenting and evaluating the results of the RI, the CSM, the BHHRA and BERA, and related documents
- Identifying ARARs and other regulatory, policy-based, and/or administrative factors to be considered (TBCs)
- Establishing RAOs and PRGs, taking into account RBTCs, ARARs, and regional background levels of COCs in relevant environmental media
- Identifying and screening general response actions (GRAs), remedial technology types, and specific process options best suited to site conditions
- Identifying candidate technologies for potential treatability studies and pilot studies, and implementing and evaluating the results of these studies
- Assembling the technology types and process options into site-wide remedial alternatives, and screening the alternatives against the threshold evaluation criteria defined under the NCP
- Estimating volumes and areas of sediment to be addressed by active remedial measures under each alternative
- Estimating the ability of each alternative to achieve RAOs and PRGs by applying the hydrodynamic, sediment transport, contaminant fate and transport, and bioaccumulation models developed in the RI/FS to project future sediment and tissue recovery

- Evaluating residual risk for contamination left in place at the conclusion of the remedial activities under each alternative
- Completing the detailed evaluation and comparative analysis of remedial alternatives based on the remedy evaluation criteria defined in the NCP, concluding with a recommended preferred remedy.

Many of these activities, while shown as sequential steps, will be conducted in parallel. The FS will also build on activities completed to date, including the RM 10.9 removal action, the technology screening evaluations performed as part of the EPA FFS (LBG 2014), and treatability and pilot studies performed by EPA (LBG 2014; USEPA 2012; BioGenesis 2009; GTI 2008) and the CPG (CH2M Hill 2012a,b).

1.2.4 USEPA Sediment Guidance Guiding the LPRSA FS

The EPA Sediment Guidance identifies critical considerations for effectively conducting the FS process at contaminated sediment sites (USEPA 2005). The document supplements existing EPA guidance by offering sediment-specific guidance on critical issues, including numerical modeling, development of remedial alternatives, application of the NCP remedy selection criteria, identification of ARARs, evaluation of effectiveness and permanence, cost estimation, and use of institutional controls.

Several challenges described in the EPA Sediment Guidance associated with contaminated sediment sites are particularly applicable to the FS for the LPRSA:

- Sediment sites may have a large number of sources, some of which can be ongoing and difficult to control. In the LPRSA, upstream and downstream sources (caused by tides) and tributaries may require consideration during the evaluation of remedial action alternatives.
- Sediment environments are dynamic. Tidal action, storm surge, and changes in river flows, as well as navigational dredging and urbanization, represent the changing natural and anthropogenic factors that have affected the LPRSA in the past and continue to do so today.
- The LPRSA is considered a "megasite" and is both very large and very complex. For more than 200 years, there have been myriad chemicals and contaminants released to the LPR from numerous industrial and municipal sources. Within the watershed are numerous non-Hazardous Substance List stressors and potential sources of contaminants to the LPR, as well as the aggregate impacts of years of industrial and urban discharges to the river system.
- Cleanup work in an urbanized aquatic environment is difficult and costly. Active measures such as dredging and capping in the LPRSA will present significant challenges

and costs. Furthermore, the dynamic nature of the river can result in the resuspension of sediment during remediation, which can present short-term risk and affect the remedy. The urban setting of the LPRSA introduces a range of challenges and constraints for remedy implementation, including:

– Numerous low clearance bridge crossings, coupled with high uncertainty about the condition, availability, and ability of bridges to be opened frequently throughout the multi-year construction time frame, will impact dredging and capping production rates.

– Upland transportation infrastructure will be stressed by barge and truck activity required to transport dredged sediment and capping/backfill materials. These impacts on the upland transportation network may be compounded by delays associated with the bridge openings required for barge traffic. The capacity of the existing rail system is uncertain and may be a rate limiting factor, potentially delaying and extending the duration of the cleanup.

– Numerous utility crossings, bridge abutments, and dilapidated shoreline structures (bulkheads, piers) will constrain dredging and capping activities. Management of these constraints will require development of safe offsets and/or engineering controls to avoid damage to infrastructure. Dredging and capping may not be achievable in some areas.

– Water depth limitations, low bridge crossing, and navigational constraints will restrict the size of equipment that can be used within the river.

The guidance also recognizes that combined approaches to cleanup are more likely to meet with success, citing examples such as the use of armored capping for erosional areas, together with thin layer capping ENR, and monitored natural recovery (MNR) in other areas, and appropriate institutional controls. Combined approaches will be considered in the development of remedial alternatives for the LPRSA FS.

Finally, in recognition of the challenges and uncertainties that accompany large-scale sediment remediation, the guidance emphasizes that flexibility should be built into the selected remedy: "Iterative or adaptive approaches to site management are likely to be appropriate at these sites." EPA has recently reemphasized and heightened the focus on adaptive management as an effective approach to cleanup of large, complex sediment sites (USEPA 2013a). As part of a comprehensive review of the Superfund program to evaluate the efficiency of the cleanup process and the effective use of resources, EPA has identified adaptive management as a significant element of the Superfund Remedial Program Review Action Plan: "While some aspects of adaptive management were used historically, this plan emphasizes integrating it more deliberately throughout the remedial process" (USEPA 2013a). The complex nature of the LPRSA and the potential need for large-scale active remediation to achieve cleanup goals suggest that an adaptive management approach could be well-suited to this site.

1.2.5 Remedy Selection

The FS will identify and screen remedial technologies based on the general range of LPR sediment characteristics, waterway conditions, and the COCs identified in the risk assessments. Detailed analyses will be performed on remedial alternatives developed from these technologies, and ultimately provide the information necessary to identify a preferred remedial action. After the FS is finalized, EPA will issue a proposed plan for public review and comment. The proposed plan will summarize the results of the FS and describe the basis for EPA's selection of a preferred alternative. After comments on the proposed plan have been evaluated and addressed, EPA will issue a ROD that documents the selected cleanup plan and the basis for its selection.

1.3 Document Organization

The remainder of this document comprises the following sections, which reflect the FSWP outline referenced in the Settlement Agreement:

- Section 2 provides a description of the history and environmental setting of the LPRSA.
- Section 3 presents the approach to developing RAOs, PRGs, and metrics to evaluate the remedial alternatives.
- Section 4 presents the process for identifying and screening remedial technologies.
- Section 5 provides the approach for developing remedial alternatives.
- Section 6 presents the process for screening remedial alternatives.
- Section 7 presents the approach for the detailed and comparative analysis of the remedial alternatives.
- Section 8 describes the FS reporting and proposed schedule.
- Section 9 contains the references.

2 SITE HISTORY AND ENVIRONMENTAL SETTING

This section presents the site history and environmental setting of the LPRSA.

2.1 SITE HISTORY

The LPRSA is located within one of the major centers of the American Industrial Revolution. Early manufacturing was established near Paterson, New Jersey, during the post-colonial era. Beginning with cotton mills, the LPR watershed, concentrated along the river, grew to include manufactured gas plants, petroleum refineries, tanneries, shipbuilding, smelting, pharmaceutical, electronic product, dye, paint, pigment, paper, and chemical manufacturing plants, and other industrial activity (Shear et al. 1996; MPI 2007a; AECOM 2011b). Major population centers such as Paterson and Newark transformed the watershed into a mix of residential, commercial, and industrial uses. Thus, like many other urban systems, the LPR has been subjected to a broad range of contaminant loadings from multiple sources (e.g., untreated industrial and municipal wastewater, combined sewer overflows [CSOs]/stormwater outfalls [SWOs], direct runoff, atmospheric deposition) for a long time. A distinguishing characteristic of the LPR is its elevated levels of 2,3,7,8-TCDD in sediments.

The Diamond Alkali site was placed on the National Priorities List in September 1984 due to 2,3,7,8-TCDD contamination detected in site soils. The Diamond Alkali facility was located at 80 and 120 Lister Avenue in Newark, New Jersey, adjacent to approximately RM 3.5 of the Passaic River. Various companies manufactured chemicals such as pesticides and phenoxy herbicides, including the primary components used to make the military defoliant Agent Orange, at this location over the years (Bopp et al. 1991, 1998; Chaky 2003; Lillienfeld and Gallo 1989). The upland site underwent several remedial actions under the oversight of NJDEP and EPA between 1984 and 2004 (USEPA 2008; Tierra 2008). It was a significant source of 2,3,7,8-TCDD and DDT to the LPRSA, and some investigators have concluded that it was the dominant source of 2,3,7,8-TCDD to the river (Bopp et al. 1991, 1998; Chaky 2003; Hansen 2002), and a significant historical DDT source (Bopp et al. 1991, 2006).

Urbanization altered the physical characteristics of the LPRSA. Significant areas of tidal marshes, wetlands, and mudflats were filled in or dredged, thus gradually transforming the LPR into a highly channelized river, with the lower 8 miles dominated by hardened shorelines (e.g., sheet pile, riprap, wood pilings; AECOM 2011b; MPI 2007a). New Jersey Route 21—a major State Road—is constructed along the western bank of the LPR. Major historical developments include the completion of the Dundee Dam and lock system in 1858 (AECOM 2011b), and the subsequent expansion of regional shipping activities to accommodate growing commercial transportation needs.

A federal navigation channel of varying depth extending from the mouth of the river (RM 0) to the Eighth Street Bridge in Wallington, New Jersey (RM 15.4) was created in the late 19th century (USACE 2010). The navigation channel had four distinct segments with four different authorized depths (USACE 2010):

- 30-ft segment (RM 0 to 2.6). The channel has an authorized depth of 30 ft mean low water (MLW) and is 300 ft wide. The mean tidal range in this segment of the river is 5.5 ft.
- 20-ft segment (RM 2.6 to 7.2). The channel has an authorized constructed depth of 20 ft MLW and is 300 ft wide. From RM 4.1 to 7.2, the channel had the same authorized width and depth; however, the project was constructed to only 16 ft MLW.
- 16-ft segment (RM 7.2 to 8.1). The channel has an authorized constructed depth of 16 ft MLW and is 200 ft wide.
- 10-ft segment (RM 8.1 to 15.4). The channel has an authorized constructed depth of 10 ft MLW and is 150 ft wide.

The channel was subject to numerous deepening and maintenance dredging activities over its first 50 years of existence. No new channel construction was authorized after 1932, but the existing channel was maintained for nearly 50 years (Figure 2-1). The river was busy with traffic during the 1940s, as the height of industrialization and manufacturing on the river coincided with World War II. Post-1950, most of the maintenance dredging focused primarily on the lower 2 miles of the channel. The last maintenance dredging conducted by USACE in 1983 removed more than 500,000 cy of sediment to a depth of 30 ft MLW in the lower 1.9 miles of the channel (USACE 2010).

2.2 ENVIRONMENTAL SETTING

The LPRSA is a large, complex site that is located within a highly urbanized and developed region of northern New Jersey. The LPRSA encompasses the lower 17.4 miles of the Passaic River, from Newark Bay to Dundee Dam. Adjacent land use is predominantly industrial in the lower few river miles (near Newark Bay) and starts to become more commercial, residential, and recreational near RM 4. Land use is increasingly residential and recreational above RM 8. The LPRSA has been industrialized and urbanized for more than two centuries; it has served as the receiving environment for industrial and municipal waste discharges since the nineteenth century. However, the river is now being used increasingly for recreational activities such as boating and fishing as parks and boat ramps are actively being restored or newly established.

Land use changes and developments have altered the ecology and limited human uses of the river and shoreline. Currently, most (approximately 70 percent) of the riverbank along the lower portion of the LPRSA riverbank (from RM 1 to 7) is composed of bulkhead and/or riprap and supports a limited amount of vegetation (Windward 2014b). The upper portion of the LPRSA riverbank (from RM 7 to 17.4) is primarily composed of bulkhead and/or riprap with overhanging vegetation and increased access is limited by NJ Route 21 on the western bank. Many municipalities and counties along the eastern bank of the LPR have published master plans that call for the expansion and improvement of parks and open space along the river, which, if implemented, will lead to greater access to the river and improved ecological habitat in the future (Borough of Rutherford and CMX 2007; City of Newark 2010; City of Newark et al. 2004; Clarke Caton Hintz and Ehrenkrantz Eckstut & Kuhn 1999, 2004; Heyer Gruel 2002, 2003). The shift in the use of the waterfront, with increased public access and recreational use, will be upstream of Sherwin Williams (approximately at RM 3.6). RM 0 to 2 will remain active for commercial use into the future, and the stretch from RM 2 to 3.6 will likely be developed into Portfields/Brownfields.

2.2.1 Physical Setting

The LPR is an integral part of the Greater Newark Bay complex, along with Newark Bay, Hackensack River, Arthur Kill, and Kill Van Kull (Figure 1-1). These water bodies are hydraulically connected through freshwater flows from the rivers to the ocean and by tidal flows that move water both inland and toward the ocean. The tidal flows also connect the Newark Bay Complex to New York Harbor and Raritan Bay (also referred to as the New York/New Jersey Harbor estuary or the Hudson-Raritan estuary).

The LPR extends from the Dundee Dam (RM 17.4) to Newark Bay (RM 0; Figure 2-2). It receives freshwater from the Upper Passaic River at the Dundee Dam, three tributaries (Saddle River, Third River, and Second River), and to a lesser extent smaller tributaries; direct discharges from CSOs, SWOs, permitted municipal and industrial discharges; and direct runoff. Groundwater contribution to the LPR is considered small relative to the freshwater flow that enters the LPR from upstream during average flow conditions (MPI 2007a).

The LPR is a partially mixed estuary with circulation and salinity patterns that are controlled mainly by a dynamic hydraulic balance between the upstream freshwater flow and the downstream brackish tidal inflow from Newark Bay. These flows and their interactions have resulted in the EPA classifying the LPR into three major sections (MPI 2007a; SEI and HQI 2011):

1. RM 17.4 to 10—Freshwater river section (river dominant)
2. RM 10 to 6—Transitional river section (mixed)
3. RM 6 to RM 0—Brackish river section (estuary dominant).

These designations are qualitative—in reality the location of the interface between fresh and saline waters (also referred to as the "salt front") is strongly influenced by the balance between the flow volume of freshwater and tidal flows, as well as the system geometry. The salt front typically moves several miles during each tidal cycle (MPI 2007a; Cañizares et al. 2009), and can reach as far upstream as approximately RM 14 under extreme low flow conditions (SEI and HQI 2011). The location of the salt front typically coincides with the location of the estuarine turbidity maximum (which is governed by the same processes that influence the location of the salt front), that is, the region of an estuary with maximum turbidity (Dyer 1995; Chant et al. 2011).

The annual average discharge at Little Falls is 1,140 cubic feet per second (cfs) (1,200 cfs at Dundee Dam, based on drainage-area proration). MPI (2007a) determined that all other inflow sources contribute less than 20 percent of the annual average freshwater inflow to the LPR. Peak daily average flows at various statistical recurrence intervals are presented in Table 2-1.[3]

Surficial sediments (delineated from side-scan sonar data [ASI 2006]) were predominantly silts below RM 8, with some silt and sandy areas along the outer bends and in shoal areas (Figure 2–3). Coarse-grained sediments were observed between RM 5.4 and 5.8, where a series of four bridges likely constrict flows and contribute to increased flow velocities and transport of finer grained sediments. Between RM 8 and RM 12.5, the surficial sediments were primarily sand and gravel, with areas of silt observed intermittently in the shoals. Above RM 12.5, the surficial sediments in the channel were silt and sand, with coarser sediments along the shoreline. Gravel, sand, and rock were predominant above RM 14.5. The side-scan sonar delineations of surficial grain size were ground-truthed during the geophysical survey with the collection of surficial sediment samples (ASI 2006), and more recent grain-size observations are also generally consistent with the side-scan sonar mapping.

Land use along the LPRSA varies considerably (Figure 2-4a–c). The lower portion of the river is dominated by high-density commercial and industrial development and rail/transportation infrastructure (Table 2-2). A strip of green space (Riverbank Park and Minish Park) runs along the western bank of the river between RM 4 and RM 5 in Newark. The shoreline along much of the lower 7 miles is bulkheaded. Land use transitions to increasingly commercial and open space upriver, with residential pockets above RM 8. Physical constraints and the primarily industrial/commercial, urban, and infrastructure land uses limit both access and exposure to sediment and surface water in the lower 7 miles.[4] Public access to the western bank between RM 7 and RM 14 is limited by Route 21—a four-lane highway running parallel to the river. The eastern bank of the river between RM 7 and RM 14 has several parks and boathouses. Within the river, mudflats and shallow areas are interspersed along the river (Figure 2-4a–c), with

[3] Based on records spanning 1896 to 2012 at the U.S. Geological Survey Little Falls gage station. The record 35,000 cfs event reported in 1903 was affected by a dam failure caused by a significant rainfall event, and, therefore, was not included in the analysis.
[4] Accessible sediment is defined as surface sediment beneath 2 ft or less of water at MLW, using USACE nominal MLW of –2.3 ft National Geodetic Vertical Datum 1929 (NGVD 29) (in the Problem Formulation Document [Windward and AECOM 2009]).

exposed mudflats during low tide and low flow conditions. The potential for exposure to accessible sediment and surface water is greater in the recreational and residential areas above RM 7, where direct access to the eastern banks of the river is possible.

2.2.2 RI Summary

The RI was performed in accordance with the LPRRP work plan (MPI et al. 2005), the LPRRP field sampling plan (FSP; Volume 1) (MPI et al. 2006a), the LPRRP draft FSP (Volume 2) (MPI et al. 2006b), and the 2007 Settlement Agreement and SOW. The RI field investigations were completed in fall 2013, with the completion of the SSP2. Field programs have been documented through a series of data summary and characterization reports (Table 2-3). The RI report is expected to be complete in late 2014. A summary of the RI will be presented in the FS report.

The FSP specified activities to be performed as part of the RI, although not all of the RI tasks were defined in the FSP, and work plans for individual tasks were prepared throughout the project. Two of the tasks originally identified in the LPRRP FSP (MPI et al. 2006a) (pore water and groundwater sampling) were not performed as part of the RI. Porewater sampling was performed as part of the RM 10.9 investigation, and these data will be evaluated for their relevance and representativeness to support the FS evaluations. No other groundwater or porewater sampling is planned to support the RI/FS.[5]

2.2.3 Background Concentrations of COPCs

Although the LPRSA RI/FS focuses primarily on historically contaminated sediment in the LPRSA, it is also important to acknowledge other potential sources of hazardous substances and environmental stressors to the LPRSA from surface water and associated suspended solids that enter the LPRSA from (1) the watershed above Dundee Dam; (2) tributaries to the LPRSA; (3) tidal inputs from Newark Bay; and (4) CSOs, sanitary sewer overflows, and point source discharges, including SWOs. These additional inputs to the LPRSA are relevant to the FS evaluation. Outside sources of COPCs may influence the long-term effectiveness and permanence of remedial activities in the LPRSA, and must be characterized to define background concentrations, incoming COPC loads, and their contribution to risk and potential future recontamination in the LPRSA.

EPA guidance recognizes that contamination at a CERCLA site may be due to releases from the site itself and contamination from other sources, including natural and/or anthropogenic sources that are not related to the site under investigation (USEPA 2002b). Accordingly, background is a factor that should be considered in risk assessment, risk management, and

[5] In a meeting with the CPG on December 17, 2013, EPA stated that it planned to conduct, jointly with the U.S. Geological Survey, a watershed-scale evaluation of groundwater flux to the LPR. If completed, this study may provide additional groundwater information to be considered in the FS.

remedy selection at CERCLA sites. The goal of a background evaluation in the context of an RI/FS is to estimate the levels of COCs that would exist in environmental media at the site in the absence of CERCLA-related releases from the site. The preferred use of reference and background information obtained from representative locations (i.e., those with the same or similar physical, chemical, geological, and biological characteristics but not affected by the activities on the site) is to develop a range of values that can be compared with data collected from within the study area. Background and reference information are not used to negate or subtract from the calculated quantitative site risk estimates. USEPA guidance (2002b) states "The contribution of background concentrations to risks associated with CERCLA releases may be important for refining specific cleanup levels for COCs that warrant remedial action (for example, in cases where a risk-based cleanup goal for a COC is below background concentrations, the cleanup level may be established based on background)".

Regional background concentrations of COCs will be established for sediment, surface water, and tissue in the BERA and BHHRA, and will be utilized in the FS to support the derivation of PRGs and the detailed evaluation of remedial alternatives. The identification of proposed reference areas for the LPRSA, procedures for the selection of background data sets, and initial statistical procedures for identifying statistical outliers in background data are described in Appendix B of the Risk Assessment and Risk Characterization Plan (RARC; Windward and AECOM [in prep]), which is currently undergoing EPA review. Existing regional data sets for surface sediment chemistry, surface water chemistry, and tissue chemistry in freshwater and estuarine areas from Delaware Bay to southern New England are being considered to determine if these data are sufficient and appropriate to define a regional background data set for the LPRSA. These data sources are being evaluated to define regional background consistent with EPA's definition of "constituents or locations that are not influenced by the releases from a site but represent an influence on the site" (USEPA 2002b).

3 REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

RAOs, under the NCP, are established in the RI/FS to specify "contaminants and media of concern, potential exposure pathways, and remediation goals" (40 CFR § 300.430(e)(2)(i)). According to EPA guidance (USEPA 1999, 2005), RAOs "describe what the proposed site cleanup is expected to accomplish." They should be clearly tied to the CSM, address the significant exposure pathways and site-specific risks to human health and the environment, be responsive to ARARs, and provide the basis for more specific PRGs/RGs. RAOs may differ for different parts of a site, regardless of whether such different areas constitute different operable units. RAOs provide a foundational consideration in the process of comparing remedial alternatives and help to focus the development and evaluation of alternatives. RAOs typically evolve over the course of the RI/FS and become final only when the ROD is signed.

The development of RAOs and their role in establishing the basis for setting PRGs/RGs for the LPRSA will be shaped by several additional specific considerations, including ARARs, RBTCs, background concentrations of COPCs and COPECs in relevant environmental media, and (where applicable) limitations of analytical chemistry data (e.g., laboratory PQLs). These considerations are addressed in the subsections below.

RAOs and the additional considerations described in the subsections below support the development and refinement of PRGs during the RI/FS process, and the selection of final RGs in the ROD. These terms are defined in the NCP and supporting guidance and are used in this document as follows:

- A PRG is a specific identification of a cleanup level (e.g., a sediment concentration or risk level) that is protective of human health and the environment for each exposure pathway. Initially, PRGs may be defined using ARARs or generic cleanup levels, but they are often reevaluated during the RI/FS process as the CSM is refined and site-specific studies, including the BHHRA, BERA, and the characterization of background conditions, become available. PRGs may be represented as a range of values corresponding to a risk level or range considered to be acceptable by EPA.
- Final RGs (or final cleanup levels) are established in the ROD and may differ from the PRGs based on selection of different target risk levels and/or exposure scenarios than were used in the development of PRGs, taking into consideration factors and tradeoffs evaluated in the nine criteria analysis under the NCP (USEPA 1999).

3.1 REMEDIAL ACTION OBJECTIVES

RAOs provide a general description of what the remedy is expected to accomplish (USEPA 1999, 2005). Under the NCP, RAOs are established in the RI/FS to specify "contaminants and media of concern, potential exposure pathways, and remediation goals" (40 CFR § 300.430(e)(2)(i)). They should be clearly tied to the CSM, address the significant exposure pathways and site-specific risks to human health and the environment, identify the COCs and environmental media to be addressed by the cleanup, be responsive to ARARs, and provide the basis for setting specific PRGs and final cleanup levels. RAOs are a foundational consideration in the development and evaluation of remedial alternatives and help to focus the process of comparing alternatives. The ability of remedial alternatives to attain the RAOs, and the time frame under which RAOs can be met, are primary considerations in the evaluation of remedial alternatives with respect to overall protectiveness of human health and the environment, long-term effectiveness and permanence, and short term effectiveness as specified in the NCP (40 CFR § 300.430(e)(9)(iii)). Finally, RAOs establish how remedy success will be defined and measured after implementation, and provide the basis for determining long-term monitoring requirements.

RAOs and PRGs typically evolve over the course of the RI/FS and become final only when the ROD is signed. The proposed RAOs for the LPRSA are provided below.

- **Human Health—Fish and Crab Consumption:** Reduce cancer risks and noncancer health hazards to people eating fish and shellfish from the LPR by reducing dietary exposures to human health risk drivers in edible fish and shellfish tissue.
- **Human Health—Direct Contact:** Reduce cancer risks and noncancer health hazards to humans who come into direct contact with LPR sediment and surface water by reducing concentrations of human health risk drivers in sediments.
- **Ecological Receptors:** Reduce risks to ecological receptors by reducing the concentrations of ecological risk drivers in exposure media.
- **Surface Water**: Reduce risks to human health and ecological receptors by reducing concentrations of human health and ecological risk drivers in surface water.
- **Contaminant Migration:** Reduce potential contaminant migration from the LPR to Newark Bay by reducing concentrations of risk drivers in surface sediments.

3.2 DERIVATION OF PRELIMINARY REMEDIATON GOALS

PRGs are initial estimates of the endpoint concentrations or risk levels for each RAO that are believed to provide adequate protection of human health and the environment, and comply with ARARs, based on available site information (USEPA 1991b,c; 1997). For the FS, PRGs will be expressed as tissue, sediment, and/or surface water concentrations for the risk drivers, depending on the RAO, and will be developed based on consideration of the following factors:

- ARARs
- RBTCs developed using the exposure scenarios, assumptions, and risk estimation methods specified in the baseline human health and ecological risk assessments
- Background concentrations, if RBTCs are lower than background concentrations.

Considerations for PRG development and selection involving these factors are described below.

3.2.1 Applicable or Relevant and Appropriate Requirements

ARARs for remedial alternatives under evaluation for the LPRSA will be compiled and evaluated in the RAO/PRG Technical Memorandum and in the FS report. ARARs are defined under CERCLA Section 121(d) as any legally applicable or relevant and appropriate standard, requirement, criterion, or limitation under any federal environmental law, or promulgated under any state environmental or facility siting law that is more stringent than the federal law.

Unless an ARAR is waived, the NCP requires compliance with ARARs during remedial actions as well as at their completion, and compels attainment of ARARs during removal actions to the extent practicable, considering the exigencies of the situation (40 CFR § 300.415(j)). For this reason, ARARs are a key consideration in the development of RAOs and—in cases where ARARs prescribe binding numeric criteria, standards, or cleanup requirements for environmental media—they can become the basis for establishing numeric PRGs and final cleanup values.

An ARAR may be either "applicable" or "relevant and appropriate," but not both. There is more flexibility in the relevance and appropriateness determination than for an "applicable" determination: a requirement may be "relevant," in that it covers situations similar to that at the site, but may not be "appropriate" to apply for various reasons and, therefore, not well suited to the site. In some situations, only portions of a requirement or regulation may be judged relevant and appropriate (USEPA 1991b).

ARARs are grouped into three types: chemical-specific, location-specific, and action-specific. Chemical-specific ARARs include laws and requirements that establish health- or risk-based numerical values or methodologies for environmental contaminant concentrations or discharge. Action-specific ARARs are requirements that define acceptable treatment and disposal procedures for hazardous substances. They generally set performance, design, or other similar action-specific controls or restrictions on particular kinds of activities related to managing hazardous substances or pollutants. These requirements are triggered by the remedial activities selected to accomplish a remedy. Location-specific ARARs are requirements that relate to the geographic position of the site. State and federal laws and regulations that apply to the protection of wetlands, construction in floodplains, and protection of endangered species in streams or rivers are examples of location-specific ARARs.

TBCs (to-be-considered information) are non-promulgated criteria, advisories, guidance, and proposed standards that are issued by federal or state governments. Although TBCs are not potential ARARs because they are neither promulgated nor enforceable, it may be necessary to consult TBCs to interpret ARARs or to determine preliminary remediation goals when ARARs do not exist for particular contaminants or may not be sufficiently protective. Compliance with TBCs is not mandatory. Examples of TBC criteria include those in the NJDEP (1997) dredging technical manual and related best management practices.

EPA may waive an ARAR for a given response action provided that at least one of the following six specific conditions is met per CERCLA Section 121(d) and 40 CFR § 300.430(f)(1)(ii)(C):

1. The alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement
2. Compliance with the requirement will result in greater risk to human health and the environment than other alternatives
3. Compliance with the requirement is technically impracticable from an engineering perspective
4. The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach
5. With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state
6. For fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of fund monies to respond to other sites that may present a threat to human health and the environment.

3.2.2 Risk-Based Threshold Concentrations

An RBTC expresses the maximum concentration of a risk-driver COC in an exposure medium that is considered protective of a particular exposure pathway and receptor. RBTCs will be calculated for the risk drivers based on the exposure assumptions and toxicological parameters used in the risk assessments. Human health RBTCs will be established for a range of risk levels (1×10^{-4} to 1×10^{-6}) for carcinogens and hazard index of 1 for noncarcinogens, consistent with EPA's 2014 FFS for the lower 8 miles of the LPR. Ecological RBTCs will be established based on a hazard quotient of 1. Specific calculation methods and the resulting RBTCs will be documented in the draft FS report for each risk-driver COCs. Receptor-specific RBTCs will be derived and presented in the RAO/PRG Technical Memorandum and the FS report for each risk-driver COC and relevant exposure pathway(s).

3.2.3 Background

An evaluation of background chemical concentrations will be presented in the baseline risk assessments and considered in the human health and ecological risk characterization. RBTCs will be compared to background as part of the process of identifying actionable levels of COCs (USEPA 2002b) and will inform the selection of PRGs.

As stated in USEPA (2002b) guidance on use of background in remediation, "generally, under CERCLA, clean-up levels are not set at concentrations below natural background levels. Similarly, for anthropogenic contaminant concentrations, the CERCLA program normally does not set cleanup levels below anthropogenic background concentrations." Consequently, in cases where RBTCs for a COC are lower than background, background will be considered together with ARARs, RBTCs, and fate and transport modeling to select the appropriate PRGs.

3.3 PERFORMANCE METRICS

Performance metrics will be developed for use in the FS to evaluate the extent to which each remedial alternative is expected to achieve the RAOs and the time frames, taking into account active remedial measures, institutional controls, and long-term recovery. In general terms, metrics will be based on model simulations to characterize the future sediment, water column and tissue concentration both during and after construction, and projections of future residual risk. These projections will be compared to levels needed to achieve PRGs as well as the time frames required to achieve such levels. The evaluation of the proposed RAOs is likely to focus on one or more of the following metrics:

- Estimates of surface sediment COC concentrations at the completion of remedial activities (prior to future concentration reductions due to natural recovery).
- Short- and long-term projections of surface sediment, surface water, and fish tissue COC concentrations that are relevant to risk projections for exposure pathways that are being evaluated in the risk assessments.
- Short- and long-term projections of surface water COC concentrations, which are directly relevant to evaluation of attainment of water quality ARARs.
- Short- and long-term projections of COC transport from the LPR to Newark Bay, considering both particulate and dissolved-phase loads.

Additional metrics may be developed, as necessary, to evaluate relevant media and exposure pathways identified in the risk assessments. Contaminant fate and transport modeling will be performed to estimate changes in sediment and water column concentrations over time for each alternative. Future fish tissue concentrations will be predicted by the bioaccumulation model. The risk projections will be performed in accordance with the procedures specified in the RARC (Windward and AECOM [in prep]). The effectiveness of monitored natural recovery will also be assessed qualitatively based on multiple, empirical lines of evidence in addition to the modeling projections. The modeling framework, including procedures and input parameters, used to generate model projections to support the FS will be approved by EPA prior to the submission of the Final FS.

4 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The identification and screening process is a step-wise approach considering GRAs, technology types, and process options that are potentially applicable to cleanup of contaminated sediments in the LPRSA. These three categories or tiers provide a systematic method to identify and evaluate various physical, chemical, and administrative "tools" available for implementing remedial actions.

4.1 PRELIMINARY GENERAL RESPONSE ACTIONS

GRAs describe in broad terms the types of actions potentially applicable to cleanup of contaminated media. Each GRA may contain one or more technology type. For example, one GRA is physical removal of contaminated sediments from the site, and two common technologies that can accomplish sediment removal are dredging and excavation. Process options are a further subdivision in the technology screening procedure, and define the specific method or type of equipment used within a technology. For example, dredging may be accomplished using process options such as clamshell dredging or hydraulic dredging.

The GRAs that will likely be considered in the FS include:

- **No Action**—CERCLA guidance and the NCP require the evaluation of a "no-action" response as a baseline for comparing to other alternatives. Under the no-action response, site conditions as defined in the RI, and human health and ecological risks (as identified in the risk assessments), would remain in place, because no remedial action would be implemented.
- **Institutional Controls**—Institutional controls are legal and/or administrative measures that limit human use or access to the site, thereby preventing or reducing exposure to COCs. Fish consumption advisories, waterway use restrictions, deed restrictions, and access restrictions are examples of institutional controls. Institutional controls currently under evaluation for the LPRSA include a fish exchange program, continuation and/or enhancement of fish advisories, enhanced community outreach, navigational restrictions, dredging restrictions, bulkhead maintenance restrictions, and signage to restrict vessel traffic in critical remedy areas (e.g., capped areas).
- **Engineering Controls**—Engineering controls are physical site restrictions that limit human use or access to the site, thereby preventing or reducing exposure to COCs. Engineering controls currently under evaluation for the LPRSA include a carp management program.

- **Monitored Natural Recovery**—MNR is a remedy for contaminated sediment that typically relies upon ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment (USEPA 2005). MNR includes regular monitoring such as the periodic collection and analysis of environmental samples (e.g., fish tissue, sediment, surface water) to measure whether human health and ecological risks are reduced to expected levels within an anticipated time frame.
- **Enhanced Natural Recovery**—ENR involves the application of thin layers or particle broadcasting of clean material over areas where natural recovery processes are already occurring to enhance natural recovery. By applying thin layers of clean sediments (i.e., enhanced physical burial) over an area and allowing natural restoration or bioturbation to mix the impacted and clean sediment layers, the natural recovery process is increased and results in a surface layer with contaminant concentrations within acceptable levels. Reactive agents can also be added to the thin layer to enhance natural recovery.
- **Containment**—Containment refers to the in-place physical isolation or immobilization of COPCs in sediment via *in situ* capping. Effective containment can result in rapid limitation of the bioavailability and mobility of COPCs present in the sediments because the underlying COPCs are isolated from biota. The typical process options for containment include capping, capping with partial sediment removal, and reactive caps. Capping may also require controls to limit resuspension during cap placement. In addition to an isolation layer, caps may require an armoring layer to prevent erosion, a habitat layer, and potential other layers.
- **Removal**—Removal refers to the physical dredging or excavation of impacted sediments. Dredging includes the removal of sediment from the site. Dredges are typically classified based on the type of process option such as mechanical or hydraulic removal. Excavation refers to removal of sediments after the water has been diverted or dewatered. Dry excavation includes shoreline and shallow nearshore areas, and can also refer to excavation during low tide conditions. Removal requires consideration of other process options, such as in-water controls to minimize sediment resuspension during removal, dewatering to reduce sediment moisture content, treatment of the water before discharge, transport of sediment, and treatment/disposal of the sediment.
- ***In situ* Treatment**—*In situ* treatment involves the in-place application of biological, chemical, or physical methods for reducing COPC concentrations or COPC bioavailability. *In situ* biological treatment includes the introduction of reagents to enhance the natural biodegradation and mineralization process of the COPCs. Chemical treatment can include oxidation to degrade or destroy the organic COPCs. Physical methods can include solidification or solidification/stabilization, which includes the application of treatment reagents such as Portland cement, pozzolan fly ash, fly ash/Portland cement mixtures, lime kiln dust, or other proprietary reagents.

- ***Ex situ* Treatment**—*Ex situ* treatment involves the biological, chemical, thermal, or physical applications of treatment technologies to transform, destroy, or immobilize COPCs following removal of the impacted sediments. Following treatment, the residual materials are typically disposed of in a landfill or, where applicable, used for other beneficial purposes.
- **Ancillary Technologies**—Ancillary technologies can include sediment dewatering, wastewater treatment, and transportation. Dewatering involves the removal of water from the removed sediment to produce a material more amenable to handling. Wastewater treatment includes treating the water from the dredged sediment to meet effluent water quality criteria for discharge to a receiving system. The methods for transportation can include combinations of barge, railroad, truck, and pipeline transport.
- **Disposal**—The main technologies for disposal include beneficial use, land disposal, and aquatic disposal. Beneficial use can include in-water beneficial use, upland beneficial use, and incorporation as daily landfill cover. Disposal is the permanent placement of sediment into a permitted and/or appropriate structure or facility. Examples of disposal process options include in-water or near-water facilities such as contained aquatic disposal (CAD) cells or confined disposal facilities (CDFs) and upland and offsite landfills.

Candidate response actions will be screened to eliminate those that cannot be implemented in the LPRSA. The remaining response actions will be further evaluated to identify specific technologies to be included in the development of alternatives.

4.2 BENCH-SCALE TESTING AND PILOT STUDIES

Since the initiation of the RI in 2003, several treatability studies have been performed to evaluate candidate remediation technologies for the LPRSA FS by both EPA and its Partner Agencies (BioGenesis 2009; GTI 2008; LBG 2014; USEPA 2012) and the CPG in support of the RM 10.9 removal action (CH2M Hill 2012a,b).

- Cement-Lock® Technology for Decontaminating Dredged Estuarine Sediments. Gas Technology Institute. November 2008
- Demonstration Testing and Full-scale Operation of the Biogenesis℠ Sediment Decontamination Process: Final Report. BioGenesis Washing BGW, LLC, Springfield, VA. December 2009
- Environmental Dredging Pilot Study Report – Lower Passaic River Restoration Project. Prepared for U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, New Jersey Department of Transportation. Louis Berger Group. July 2012

- River Mile 10.9 Removal Action – Sediment Washing Bench-scale Testing Report, Lower Passaic River Study Area – CERCLA Docket No.02-2012-2015. CH2M Hill, Inc. 2012
- Final Construction Report – Lower Passaic River Study Area – Phase 1 Removal Action, Tierra Solutions, Inc. March 2013
- River Mile 10.9 Removal Action, Final Design Report, Lower Passaic River Study Area. CH2M Hill, Inc. July 2013
- Focused Feasibility Study Report, Lower Eight Miles of the Lower Passaic River. Prepared for the U.S. Environmental Protection Agency Region 2 and U.S. Army Corps of Engineers Kansas City District. Louis Berger Group, April 2014.
- River Mile 10.9 Removal Action – Draft Final Construction Report, Lower Passaic River Study Area. CH2M Hill, Inc. August 2014 (in prep).

These studies provide sufficient basis for evaluation of candidate technologies for the FS, and no additional studies are currently planned as part of the FS. The FS will include a summary of these studies, and evaluation of the performance of the remedial technologies and the applicability of the results to full scale implementation.

4.3 IDENTIFICATION OF DISPOSAL LOCATIONS

A range of disposal options was previously evaluated for the LPRSA in association with the Tierra Phase 1 (Tierra 2008) and RM 10.9 (CH2M Hill 2013) removal actions, and by EPA in the FFS (LBG 2014). Potentially applicable disposal options include permitted offsite landfill facilities, CAD facilities, and CDFs. The findings from prior disposal studies will be evaluated and summarized in the FS and will be considered along information specific to the LPRSA FS, including the volumes and schedule of the remedial alternatives and potential technical and administrative constraints.

4.4 IDENTIFICATION AND SCREENING OF CANDIDATE TECHNOLOGIES

The results of the previously completed bench-scale testing and pilot studies will be evaluated together with experience from recent removal actions on the LPRSA and other relevant regional sites to identify candidate technologies to be considered in the FS.

The screening of potentially applicable remedial technologies and process options will consider information from recent regional and national sediment remediation projects. The evaluation and screening of technologies and process options will build directly on EPA's evaluation in the FFS (LBG 2014) and subsequent pilot studies/treatability studies performed by EPA (LBG 2014; USEPA 2012; BioGenesis 2009; GTI 2008) and the CPG (CH2M Hill 2012a,b). Published guidance and resources such as the Superfund Innovative Technology Evaluation Program, the

EPA Hazardous Waste Clean-up Information web site, and the Federal Remediation Technologies Roundtable were also referenced.

In accordance with EPA guidance, the technology screening evaluation will consider effectiveness, implementability, and cost of candidate process options. Effectiveness refers to whether a process option can address the contaminated media types and quantities, support achievement of the RAOs, and is proven and reliable. Implementability refers to whether a process option can be constructed and operated under the physical and chemical conditions of the LPR, is commercially available, is administratively feasible, and has been used on sites similar in scale and scope to the LPR. Cost refers to the cost of a process option relative to other process options for a given technology type.

The results of the screening will identify technologies that are retained, retained for consideration during remedial design, and not retained for further consideration. The screening will not preclude reexamination of technologies during the remedial design phase of the cleanup. Rather, the screening will facilitate a streamlined approach to the development and evaluation of remedial alternatives.

5 DEVELOPMENT OF ALTERNATIVES

A set of remedial alternatives will be developed for the LPRSA in a manner consistent with CERCLA guidance (USEPA 1988). The FS will present the rationale, assembly, and description of the alternatives. It is anticipated that there will be a set of engineering elements common to all alternatives, as well as specific evaluations (e.g., delineation of target areas) that will be applicable to a subset of the alternatives.

5.1 ENGINEERING ASSUMPTIONS AND CONSTRAINTS

A set of engineering assumptions and technical and administrative considerations applicable to the implementation of the remedial alternatives will be developed. Engineering assumptions will support the development of the remedial alternatives for the following elements:

- Sediment removal
- *In situ* and/or *ex situ* sediment treatment
- Material transport, processing, and disposal
- Capping
- MNR/ENR
- Monitoring
- Adaptive management
- Institutional controls
- Engineering controls
- Navigation and future waterway use
- Habitat considerations
- Sea level rise
- Construction sequencing and constraint
- Early actions.

5.2 DEVELOPMENT AND APPLICATION OF REMEDIAL ACTION LEVELS

This section describes the derivation of RALs and their application to delineate target areas that may be actively remediated under one or more of the remedial alternatives that will be developed and evaluated in the FS. At many sites, attaining a final cleanup level will not be achieved solely by active remediation and will rely in whole or part on natural recovery processes occurring over time. There are also circumstances in which cleanup levels can be attained on the basis of a site-wide average or exposure unit average by cleaning up targeted areas where concentrations exceed a defined action level. For these reasons, the use of RALs will be considered in the development of remedial alternatives for the LPRSA FS. RALs define levels of contaminants in environmental media above which active remedial measures, such as treatment, capping, or removal, may be implemented.

RALs have been used at several CERCLA sites in multiple EPA regions. Some examples are described briefly below:

- The Fox River ROD for OU1 and OU2 (WDNR and USEPA 2002), defines a RAL as "a PCB concentration in sediment used to define an area or volume of contaminated sediment that is targeted for remediation."
- The Lower Duwamish Waterway Proposed Plan (USEPA 2013b), defines RALs as "contaminant-specific sediment concentrations that will be used to identify specific areas of sediments that require active remediation (dredging, capping, enhanced natural recovery [ENR], or a combination thereof), taking into consideration the human health and ecological risk reduction that could be achieved by the different remedial technologies…."
- The Grasse River ROD (USEPA 2013c) does not specifically use the term RAL, but applies the concept of an action level: "EPA chose an action level of 1 mg/kg for PCBs in sediment based on the action level's projected ability to achieve EPA's PCB target concentrations in fish for protection of human health, and to achieve the remedial goal for PCBs in fish that is protective of ecological receptors."

The development and application of RALs for the LPRSA will be presented for EPA review in the Remedial Alternatives Screening Memorandum (see Section 8.1).

RALs (defined in Section 1.2.1) differ from PRGs/RGs/cleanup levels, which identify the ultimate risk-reduction or ARAR-based goals to be achieved by the remedial action. In contrast, RALs define the sediment concentration(s) above which active remedial measures (i.e., dredging or capping) would be taken under a given remedial alternative to reduce concentrations in sediment sufficiently to reach a target risk level (e.g., a PRG) within a specified time frame, taking into account both temporal factors (e.g., natural recovery) and spatial considerations (e.g., relevant risk-based scales of exposure).

RALs will be considered as a basis for defining target areas for active remediation for one or more of the remedial alternatives. Some possible approaches for developing RALs include attaining one or more risk-based cleanup levels (or interim risk reduction targets) at the completion of active remedial measures, consideration of areas with buried contamination potentially subject to future erosion, identification of slowly recovering areas, evaluation of contaminant probability distribution functions, and application of a general optimization method known as "knee of the curve" analysis. The latter approach explores the progressive reduction in SWAC as a function of incremental reductions in the acres to be remediated, which can be related to candidate RALs for risk drivers (i.e., identifies the point of diminishing returns). This type of analysis, which utilizes graphical methods in which SWAC is plotted again remediated acres, recognizes that the extent of benefit from the target area remediation is a function of the area to be remediated, but at some point the remediation of additional areas provides little additional benefit relative to the increased duration and level of effort.

Any approach to the development of RALs will entail uncertainty given the uncertainty in the data used to develop them (e.g., small scale variability in contaminant concentrations or variable spatial coverage in interpolated sediment data). The uncertainty inherent in the RALs will be considered in the FS in the development and evaluation of remedial alternatives that rely on RALs.

The development of RALs and the identification of target areas for one or more remedial alternatives on the basis of their application will be presented in the Remedial Alternatives Screening Technical Memorandum (see Section 8.1). RAL development will be supported by the Draft RI Report (Anchor QEA [in prep]), which evaluated sediment stability, areas that may be providing ongoing sources of contaminants, and areas that pose the greatest human and ecological risk. The target area boundaries will be delineated by integrating multiple physical and chemical data sets. The FS will present a detailed evaluation of the target area identification and delineation.

5.3 METHODS FOR EVALUATING RECOVERY AND RECONTAMINATION POTENTIAL

Natural recovery occurs because of several processes that cause contaminant concentrations in the surface sediment layer to decline. Deposition in the LPRSA introduces particles that typically have a lower concentration than in the surface layer largely because the major sources of new particles are the watershed above the Dundee Dam and Newark Bay, which typically exhibit lower concentrations for 2,3,7,8-TCDD and similar or lower concentrations for many other COCs or COPCs than are found in the LPR surface sediments. These particles are mixed into the surface sediments (i.e., down-mixed) and reduce concentration by dilution. Sedimentation, which occurs if deposition exceeds erosion, reduces surficial concentrations over time by progressive burial of the higher concentrations. Tidal resuspension of fluff-layer contaminants to the water column provides an additional loss mechanism, although the impact of this flux on recovery may be nominal under normal tidal conditions given the slow exchange processes that transfer contaminants from the parent bed (e.g., diffusion). Likewise, diffusion to the water column from sediment pore water is typically considered a minor factor in surface sediment recovery.

Estimates of rates of natural recovery have been developed through evaluation of sediment COPC concentrations and radiochemical data in the Draft RI Report (Anchor QEA [in prep]). Ongoing and future natural recovery will be evaluated through multiple lines of evidence, including data evaluation and numerical model projections. The FS will present an evaluation of recovery of the LPR to support evaluation of the remedial alternatives that include natural recovery.

The FS will present an evaluation of potential for recontamination of areas where active remedial measures are components of the remedial alternatives. The potential for recontamination is an important consideration in assessing the long-term effectiveness and permanence of active remedial alternatives. Available evidence indicates there are upstream, downstream, and other sources that may limit the achievable benefit of active remediation due to the potential for recontamination from these sources. The recontamination potential evaluation will be based on model predictions of sediment COC concentrations over time due to recontamination that may result from deposition of incoming sediment loads in the remediated areas and resuspension of unremediated sediments. Key uncertainties will be identified and described regarding the extent to which long-term COC concentration reductions may be achieved by active remediation of the LPR in the absence of region-wide source control.

5.4 PRINCIPAL THREAT WASTE

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a site wherever practicable (NCP § 300.430(a)(1)(iii)). EPA guidance defines principal threat waste as a source material that is highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur, such as drummed waste or pools of nonaqueous-phase liquids (USEPA 1991a). Sediment removed during both the Phase 1 and RM 10.9 removal actions were not identified as principal threat waste, and no direct evidence has been found of nonaqueous-phase liquids in the LPR sediments.

5.5 ASSEMBLING THE REMEDIAL ALTERNATIVES

A set of remedial alternatives that are expected to achieve the RAOs in the LPRSA will be assembled. The alternatives will include a no-further-action alternative, as required by the NCP, and is expected to include alternatives that span a range of areas and volumes to be remediated. Development of the alternatives will also consider a range of candidate technologies and process options that are retained from the technology screening to address contaminated sediments (e.g., removal, capping, ENR, *in situ* treatment, and MNR) and to manage and dispose dredged materials (e.g., stabilization, dewatering, *ex situ* treatment, and disposal).

Additional detail will be developed for each alternative concerning equipment and methods associated with the major remedial approaches (e.g., potential natural recovery processes, stabilization capping, dredging). Alternatives will be described with sufficient detail to allow differentiation between alternatives during their screening (Section 6) and detailed and comparative evaluation (Section 7).

It is anticipated that one or more alternatives will incorporate an adaptive management strategy to address residual risk and the inherent uncertainties involved in a large scale sediment cleanup. Experience at other complex sediment sites points to the value of using adaptive management strategies, as recommended by EPA guidance (USEPA 2005), NRC (2007), and other independent, scientific peer reviews of sediment sites throughout the country (USACE 2008a,b; Cannon 2006). EPA defines adaptive management at Superfund sites as:

> …an iterative approach to site investigation and remedy implementation that provides the opportunity to respond to new information and conditions throughout the lifecycle of a site. Adaptive management assumes there is an explicit intent to respond to new information and conditions, and to the extent it can be done under CERCLA and the NCP site decision making, formal remedial decision documents as well as other project plans and reports incorporate appropriate language that enables efficient planning and execution of adaptive management techniques (USEPA 2013a).

This provides for a systematic remedial approach that promotes efficient use of resources and reduces short-term impacts on surrounding communities. Monitoring provides a basis for assessing and determining the need for additional contingency measures if a remedy is performed under an adaptive management framework (USEPA 2005). Adaptive management can assure the success of remedial actions, in that progress is routinely assessed and actions adjusted to reflect up-to-date environmental conditions. If incorporated into a remedy, the adaptive management framework would be based on site-specific conditions and recovery goals.

6 SCREENING OF ALTERNATIVES

A range of remedial alternatives will be developed in the FS that combine the various retained technologies in a manner designed to meet project RAOs. As specified in the AOC (USEPA 2007), the core set of alternatives will be based on combinations of the three major approaches for management of contaminated sediments: natural recovery; *in situ* capping; and removal (with treatment or disposal). Innovative technologies such as *in situ* treatment, will be considered, where appropriate, as elements in the alternatives. The alternatives will then be screened to determine which alternatives are carried forward for detailed analysis. The screening process will be consistent with the NCP and as described in EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988) and presented in the Remedial Alternatives Screening Technical Memorandum.

The EPA Sediment Guidance describes the methodology for screening remedial alternatives based on estimates of their effectiveness, implementability, and cost:

- **Effectiveness** addresses the ability of an alternative to reliably protect human health and the environment (i.e., to achieve RAOs) over the long-term by reducing the toxicity, mobility, or volume of contaminants.
- **Implementability** encompasses both technical and administrative considerations. An alternative is implementable from a technical standpoint if it can be constructed and operated under site-specific conditions. An alternative is implementable from an administrative standpoint if it can be permitted, constructed, and operated in compliance with regulations. Coordination with other government entities is also considered.
- **Cost**, including both capital and operation and maintenance (O&M) costs, of each alternative is important to the screening process as it enables differentiation between high-cost, low-risk-reduction alternatives and those that achieve comparable risk reduction at lower cost. The cost criteria include an evaluation of the potential range of capital and O&M costs. Consistent with EPA's Guide to Developing and Documenting Cost Estimates during the Feasibility Study (USEPA 2000), the accuracy of an FS cost estimate will range from approximately –50 to +100 percent.

Because of the scale and complexity of the LPRSA, variability in physical characteristics, and a broad distribution of contaminants in the LPR, the development of alternatives will consider the use of adaptive management approaches to the remediation. If an adaptive management approach is used for one or more of the remedial alternatives developed for the FS, it will be necessary for the alternatives definition step to provide a description of the monitoring program that will be implemented to evaluate progress towards achieving RAOs, and the decision making process based on monitoring results.

7 DETAILED AND COMPARATIVE ANALYSIS OF ALTERNATIVES

A detailed analysis of the remedial alternatives for the LPRSA will be performed according to the standard criteria specified by USEPA (1988) and the NCP. A comparative evaluation of the remedial alternatives under CERCLA will be conducted to assess the relative performance of each alternative with respect to evaluation criteria, and to identify key tradeoffs.

7.1 FS EVALUATION CRITERIA AND METHODS

USEPA (1988) and the NCP (40 CFR Section 300.430(e)(9)([iii)) require consideration of nine evaluation criteria to address the CERCLA statutory requirements. These nine evaluation criteria are categorized into three sets of criteria that serve as the basis for conducting the detailed analyses and for subsequently selecting an appropriate remedial action.

Threshold Criteria

Under CERCLA, each alternative must meet two threshold criteria to be eligible for selection as the preferred alternative.

1. Overall protection of human health and the environment: Addresses the degree to which the alternative achieves and maintains protection of human health and the environment.
2. Compliance with ARARs: Addresses whether the alternative complies with ARARs or if a waiver is justified; and whether the alternative is consistent with other criteria, advisories, and guidance that are to be considered.

Primary Balancing Criteria

The NCP establishes five primary balancing criteria that are used, in combination, to weigh effectiveness, implementability, and cost tradeoffs among alternatives. These criteria represent the main technical criteria upon which alternative evaluation is based.

1. Long-term effectiveness and permanence: Addresses the magnitude of residual risk following remedy implementation and the adequacy and reliability of controls.
2. Reduction of toxicity, mobility, and volume through treatment: Addresses (i) the treatment or recycling processes the alternatives employ; (ii) the amount of contaminants that will be destroyed, treated, or recycled; (iii) the degree of expected reduction in toxicity, mobility, or volume; (iv) the degree to which the treatment is

irreversible; (v)the type and quantity of residuals that will remain; and (vi) the degree to which treatment reduces the inherent hazards posed by principal threats at the site.

3. Short-term effectiveness: Addresses the effects of the alternative during construction/implementation; effectiveness and reliability of protective or mitigative measures; ability to protect the community and workers during construction and the length of time until RAOs are achieved.
4. Implementability: Addresses the ease or difficulty of implementing an alternative given its technical feasibility, administrative feasibility, and availability of services and materials to construct and operate the remedy.
5. Cost: Evaluates the estimated capital and O&M costs associated with the alternative. Cost estimates will be prepared in accordance with the provisions of RI/FS guidance (USEPA 1998) and the cost estimating guide (USEPA 2000).

Modifying Criteria

Modifying criteria are state acceptance and community acceptance, which are considered by EPA during remedy selection and ROD preparation. Modifying criteria will be evaluated after the FS is released for regulatory and public review, following analysis of public comment on EPA's proposed plan.

1. State acceptance: Considers state positions and/or concerns related to the preferred alternative and other alternatives; and the state's comments on ARARs or the proposed use of waivers.
2. Community acceptance: Considers support, opposition, or concerns expressed by interested members of the community regarding the preferred alternative or other alternatives.

The NCP evaluation criteria are intended to provide a framework for assessing the risks, costs, and benefits for each remedial alternative. In the FS, the relative performance of each alternative will be assessed individually and comparatively with respect to the first seven of the nine CERCLA evaluation criteria to identify the key tradeoffs among them. The last two criteria are considered modifying criteria and are typically assessed by EPA following agency and public comment on the FS in development of EPA's proposed plan.

7.2 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

A comparative evaluation of the LPRSA remedial alternatives will be developed to assess the relative performance of each with respect to the CERCLA evaluation criteria and to identify key tradeoffs.

The alternatives will first be evaluated to assess whether they achieve or do not achieve the two threshold criteria. The alternatives that pass the threshold criteria will then undergo a detailed comparison using the five balancing criteria. Modifying criteria (i.e., state and community acceptance) will not be taken into account in the FS because these criteria will be addressed by EPA in the development of the proposed plan and ROD.

8 REPORTING AND SCHEDULE

The FS deliverables will include a draft and final FS report, along with the interim FS deliverables specified in paragraph 37 of the AOC (USEPA 2007) and Section F of the associated SOW. In a letter dated January 24, 2014, the CPG requested that EPA modify the AOC/SOW requirements for the interim deliverables. The CPG made this request in light of the significant progress that has been made on many key components of the RI/FS since the AOC was executed in 2007, and to support the expedited completion and agency review of the draft FS report. In a response dated February 18, 2014, EPA notified the CPG that was not willing to relieve the CPG of the obligation to submit the interim deliverables, but was willing to adopt a streamlined process (i.e., eliminating the requirement for agency review and approval of the FS technical memoranda described below) before proceeding with preparation of the FS report.

8.1 TECHNICAL MEMORANDA

The following interim deliverables will be submitted to EPA:

- RAO/PRG Technical Memorandum
- Remedial Alternatives Screening Technical Memorandum/Identification and Evaluation of Candidate Remediation Technologies
- Remedial Alternatives Evaluation Technical Memorandum.

Development of the FS report will proceed during EPA review of these memoranda.

8.2 DRAFT AND FINAL FS REPORT

In conformance with Section X (USEPA Approval of Plans and Other Submissions) of the Settlement Agreement, a draft FS report will be submitted to EPA for approval. The draft FS report will present the results of the FS tasks described in this work plan and will incorporate key findings of the RI, the risk assessments, modeling, and the treatability studies. After receipt of EPA's comments, the draft FS report will be revised and resubmitted for review and possible additional comment. EPA will approve the final FS report.

The FS report will consist of the following sections, in accordance with the suggested format described in Table 6-5 of EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA 1988) and expanded to reflect the current status of the LPRPR RI/FS:

- Section 1 (Introduction) will describe the regulatory setting and FS process.
- Section 2 (Study Area Setting, Remedial Investigation Summary, and Current Conditions) will describe the environmental setting of the LPRSA, summarize the results of the RI, and present a CSM for the LPRSA.
- Section 3 (Summary of Study Area Risks) will provide an overview of the results of the BHHRA and BERA.
- Section 4 (Remedial Action Objectives and Preliminary Remediation Goals) will present the proposed RAOs, additional management goals, ARARs, and PRGs for the LPRSA. Supporting technical evaluations (e.g., bioaccumulation modeling) for PRG development will be summarized as well.
- Section 5 (Modeling to Support the Evaluation of Remedial Alternatives) will summarize the technical approach and results of quantitative modeling of hydrodynamics, sediment transport, and contaminant fate and transport, and bioaccumulation in the LPRSA.
- Section 6 (Remedial Action Levels and Natural Recovery Evaluation) will describe the basis for developing RALs. It will also describe the methods that will used in the FS to evaluate natural recovery in the LPRSA, and to project ongoing/future natural recovery under various remedial alternatives, using a combination of empirical lines of evidence and model-based projections.
- Section 7 (Identification and Screening of Remedial Technologies) will describe a broad array of known potential technologies for sediment remediation and disposal and the screening of those technologies to identify representative process options based on site-specific factors.
- Section 8 (Development of Remedial Alternatives) will describe the full remedial alternatives that will be assembled for detailed evaluation based on an integrated consideration of the RAOs, PRGs, RALs, target areas, and the results of the technology screening. The development of RALs and delineation of target areas will be presented. A no-action alternative will be included in the evaluation, as required under CERCLA.
- Section 9 (Detailed Evaluation of Remedial Alternatives) will evaluate the remedial alternatives individually against the seven threshold and balancing criteria defined under CERCLA and in accordance with the specific steps and guidelines described in EPA guidance (USEPA 1988).
- Section 10 (Comparative Analysis of Remedial Alternatives) will build on the detailed evaluation of individual alternatives by directly comparing their performance against the seven CERCLA threshold and balancing evaluation criteria.

An executive summary will be provided at the beginning of the FS report.

Supporting analyses may be presented in one or more technical appendices to the FS report.

8.3 SCHEDULE

The following are proposed dates for FS submittals to EPA:

Document	Date
RAO/PRG Technical Memorandum	No later than April 3, 2015 (60 days following EPA approval of FSWP)
Remedial Alternatives Screening Technical Memorandum/Identification and Evaluation of Candidate Remediation Technologies	No later than May 4, 2015 (90 days following EPA approval of FSWP)
Remedial Alternatives Evaluation Technical Memorandum	No later than June 2, 2015 (120 days following EPA approval of FSWP
Draft FS Report	No later than July 2, 2015 (150 days following EPA approval of FSWP)

9 REFERENCES

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AECOM. [in-prep]-b. High volume chemical water column monitoring sampling program characterization report. Lower Passaic River Study Area RI/FS. Prepared for the Lower Passaic River Cooperating Parties Group. AECOM, Chelmsford, MA.

AECOM. [in prep]-c. Low resolution coring supplemental sampling program 2 characterization summary. Lower Passaic River Study Area RI/FS. Prepared for the Lower Passaic River Cooperating Parties Group. AECOM, Chelmsford, MA.

AECOM. [in prep]-d. 2009/2010 Physical water column monitoring sampling program characterization report. Lower Passaic River Study Area RI/FS. Prepared for the Lower Passaic River Cooperating Parties Group. AECOM, Chelmsford, MA.

AECOM. [in prep]-e. Baseline human health risk assessment for the Lower Passaic River Study Area. Draft. Prepared for Lower Passaic River Cooperating Parties Group. AECOM, Chelmsford, MA.

AECOM. 2009. Feasibility study work plan, Lower Passaic River Restoration Project, revised draft. Prepared for the Lower Passaic River Cooperating Parties Group. AECOM, Inc. March.

AECOM. 2010a. Quality assurance project plan for Lower Passaic River Restoration Project: Periodic bathymetric surveys. Rev. 2. AECOM, Westford, MA. May.

AECOM. 2010b. Quality Assurance Project Plan/Field Sampling Plan Addendum, Remedial Investigation Water Column Monitoring/Physical Data Collection for the Lower Passaic River, Newark Bay, and Wet Weather Monitoring, Rev. 4. AECOM, Westford, MA.

AECOM. 2011a. Quality assurance project plan, Lower Passaic River Restoration Project. Quality assurance project plan/field sampling plan addendum. RI water column monitoring/small volume chemical data collection. Rev. 3. Prepared for the Lower Passaic River Cooperating Parties Group. AECOM. July.

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FIGURES

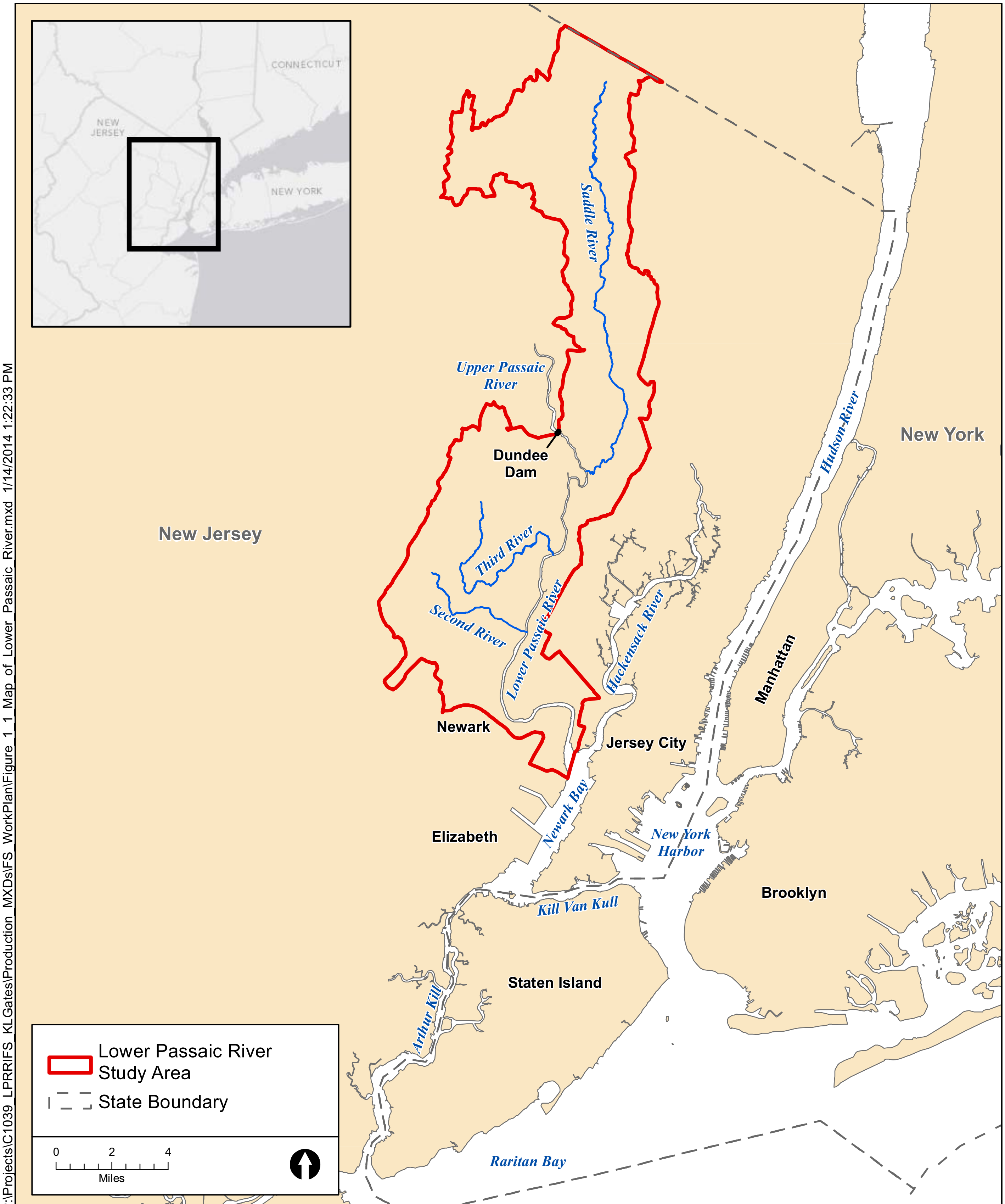

Figure 1-1.
Lower Passaic River and Surrounding Regions
Feasibility Study Work Plan, LPRSA RI/FS

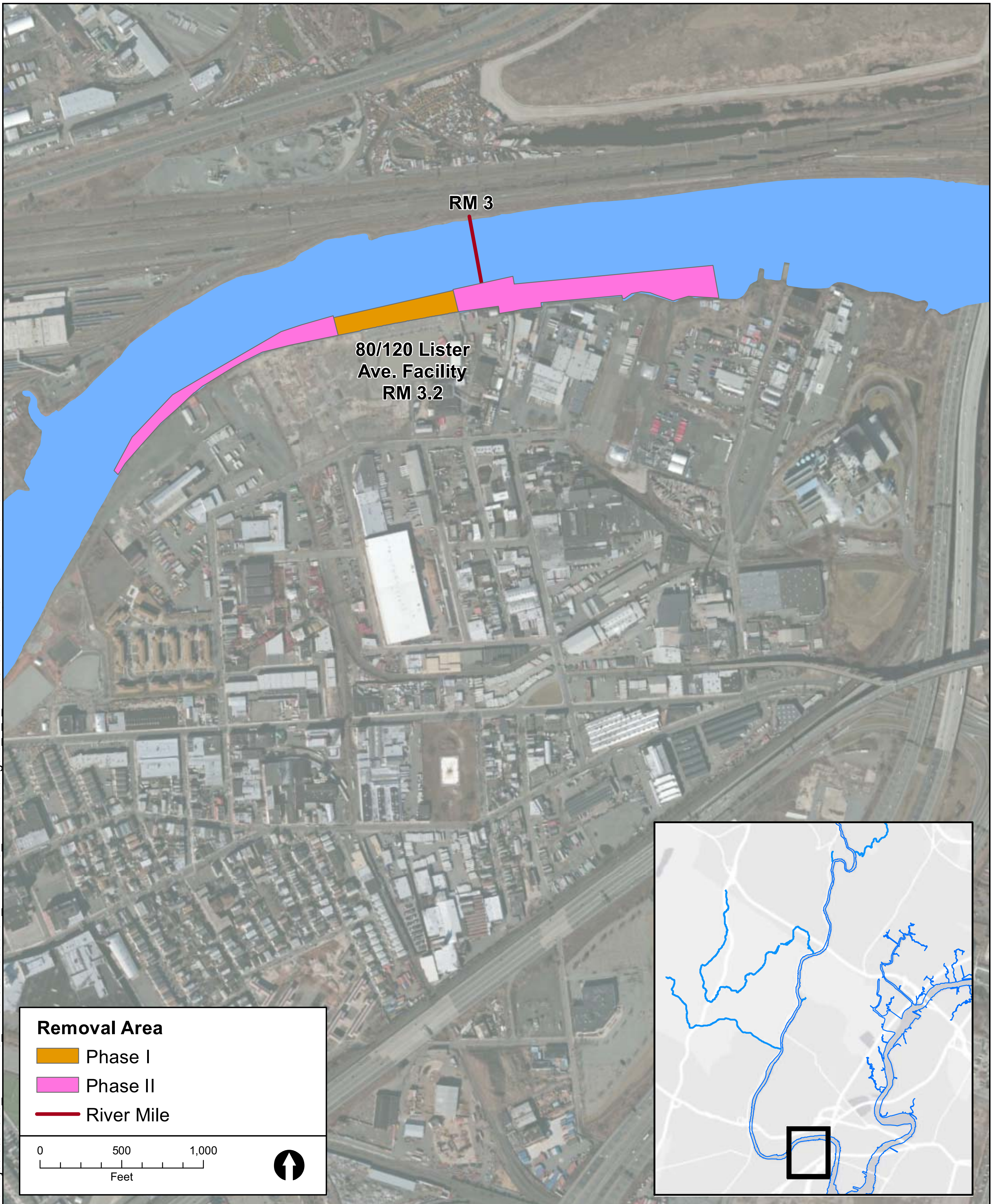

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Figure 1-2.
Phase 1 and Phase 2 Removal Action Areas
Feasibility Study Work Plan, LPRSA RI/FS

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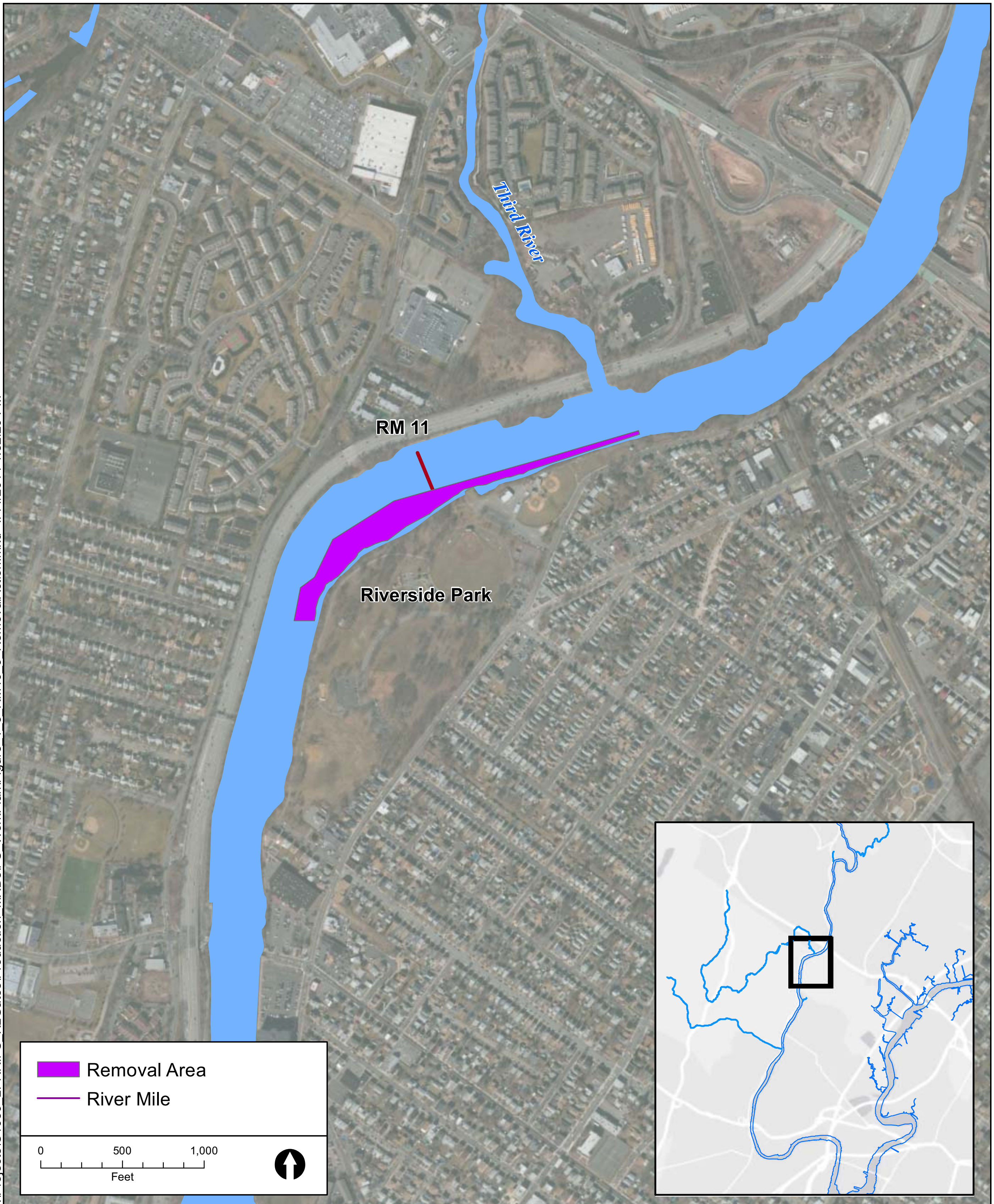

Figure 1-3.
River Mile 10.9 Removal Action Area
Feasibility Study Work Plan, LPRSA RI/FS

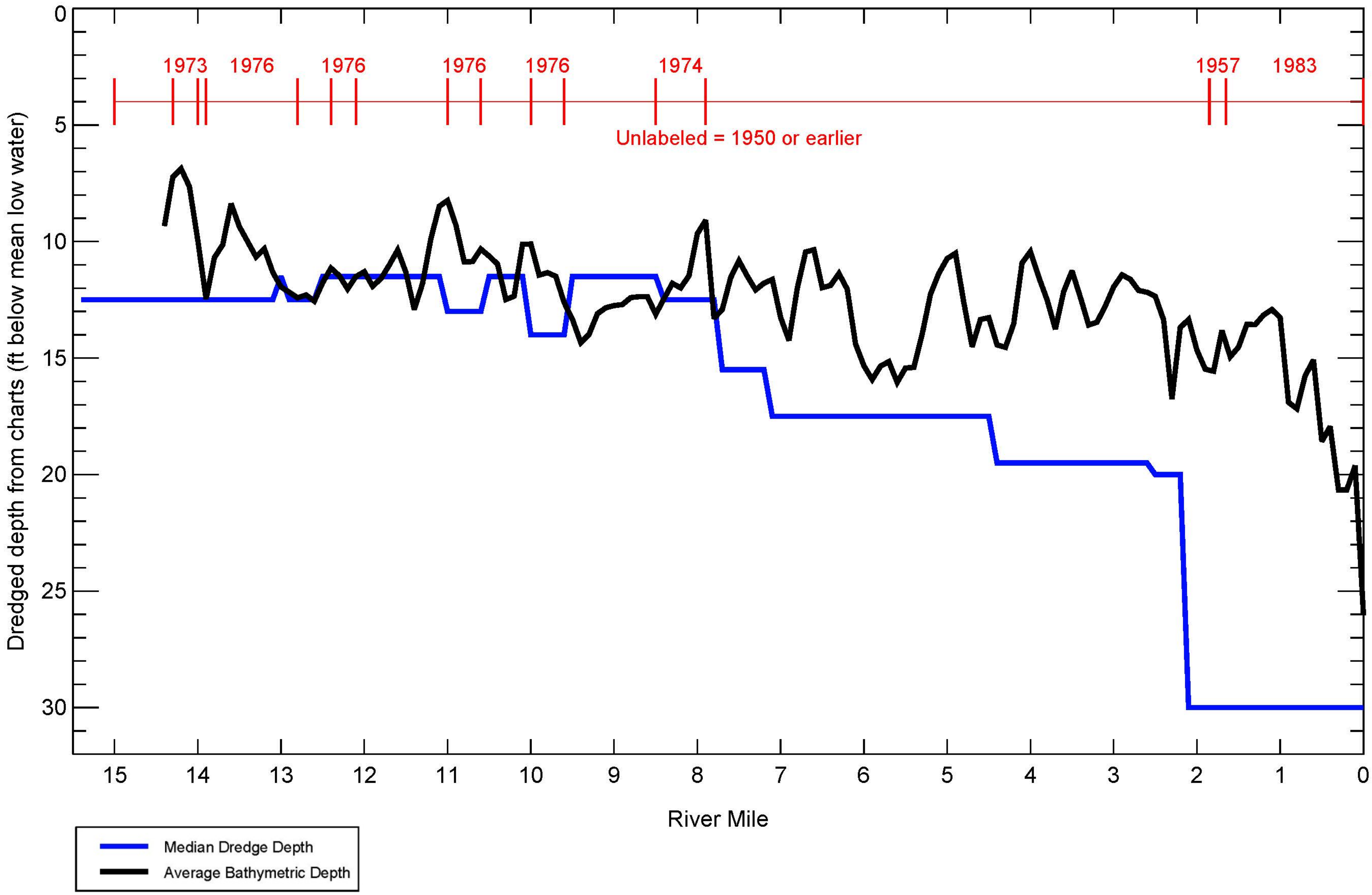

Figure 2-1.
Dredging History in the Lower Passaic River and Average Navigation Channel Depth

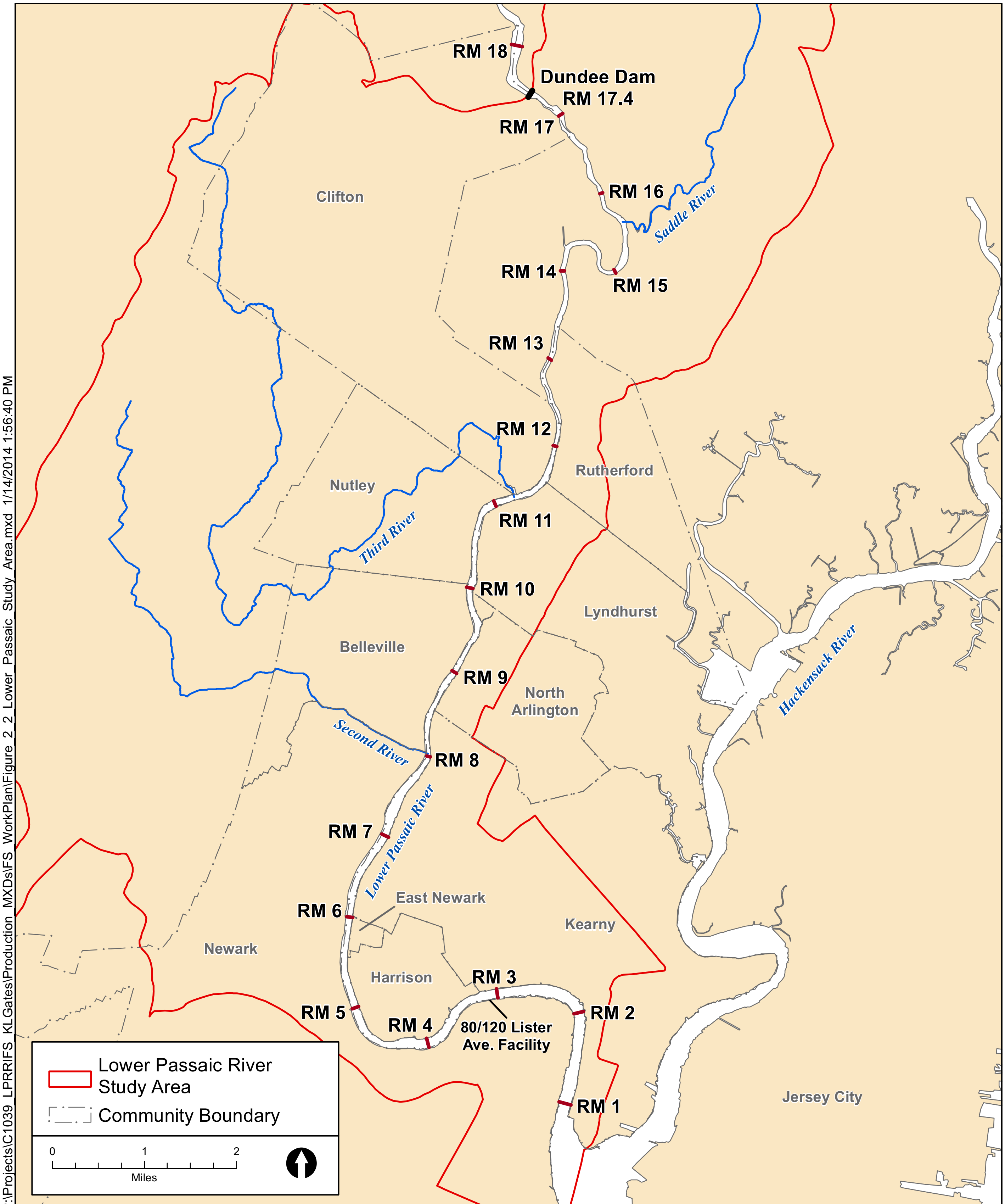

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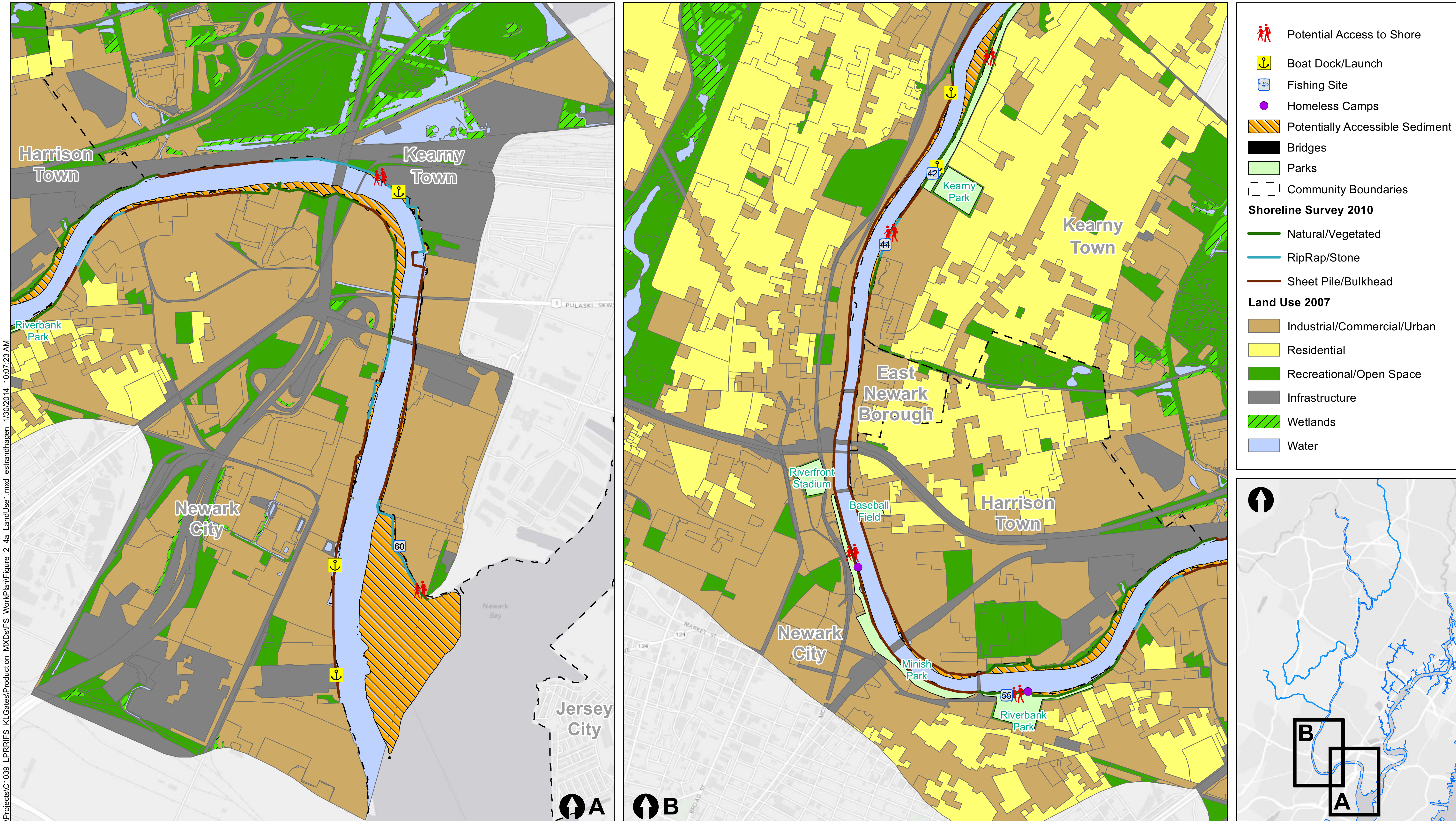
Figure 2-2.
Lower Passaic River Study Area
Feasibility Study Work Plan, LPRSA RI/FS

0 1,000 2,000
Feet

Silt
Silt and Sand
Sand
Gravel and Sand
Rock and Coarse Gravel
River Mile

Figure 2-3.
Surficial Sediment Texture
Feasibility Study Work Plan, LPRSA RI/FS



Potential Access to Shore
Boat Dock/Launch
Fishing Site
Homeless Camps
Potentially Accessible Sediment
Bridges
Parks
Community Boundaries

Shoreline Survey 2010

Natural/Vegetated
RipRap/Stone
Sheet Pile/Bulkhead

Land Use 2007

Industrial/Commercial/Urban
Residential
Recreational/Open Space
Infrastructure
Wetlands
Water

0 2,000 4,000
Feet

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Figure 2-4a.
LPRSA Land Use and Shoreline Features
Feasibility Study Work Plan, LPRSA RI/FS

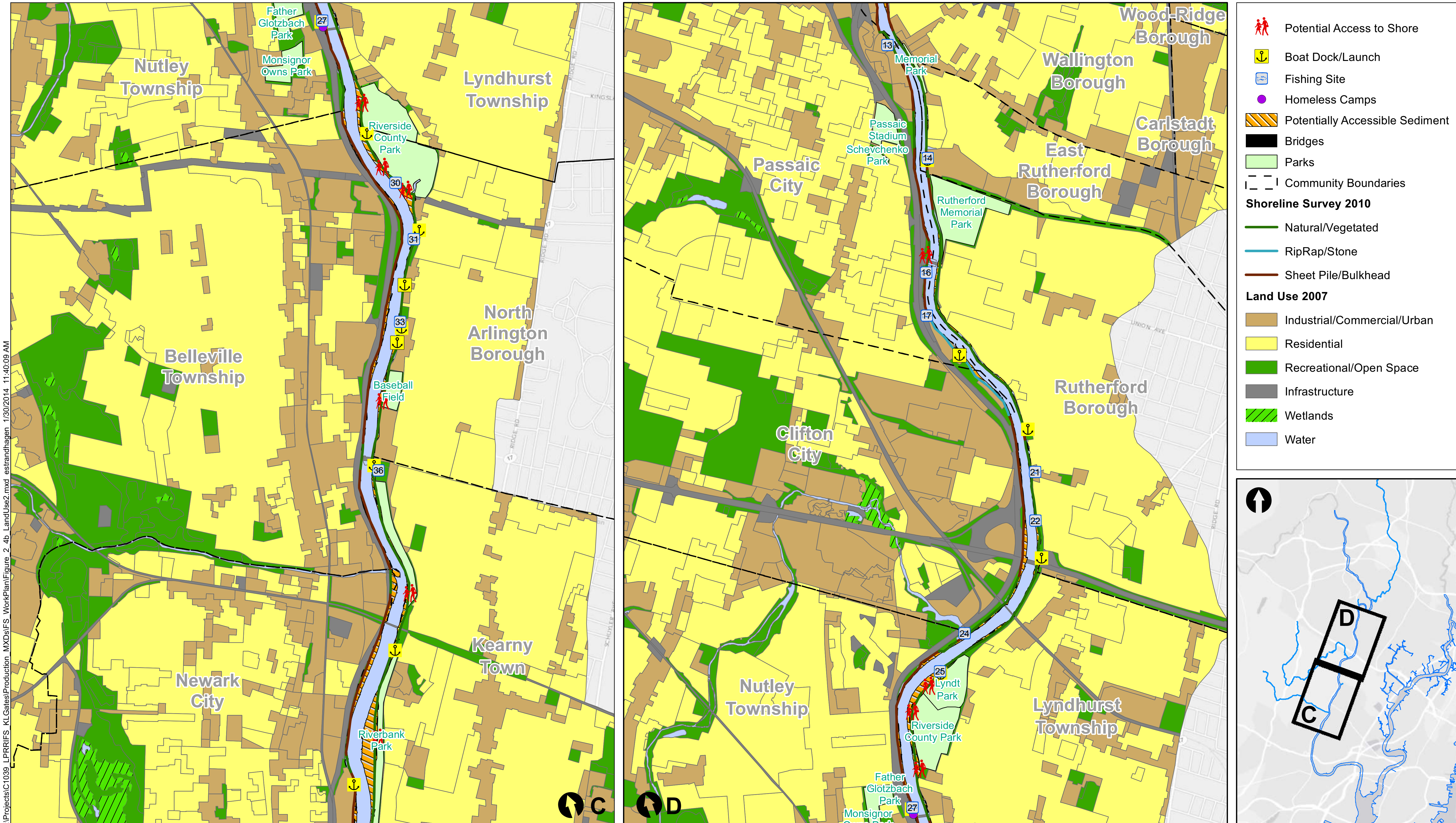

Figure 2-4b.
LPRSA Land Use and Shoreline Features
Feasibility Study Work Plan, LPRSA RI/FS

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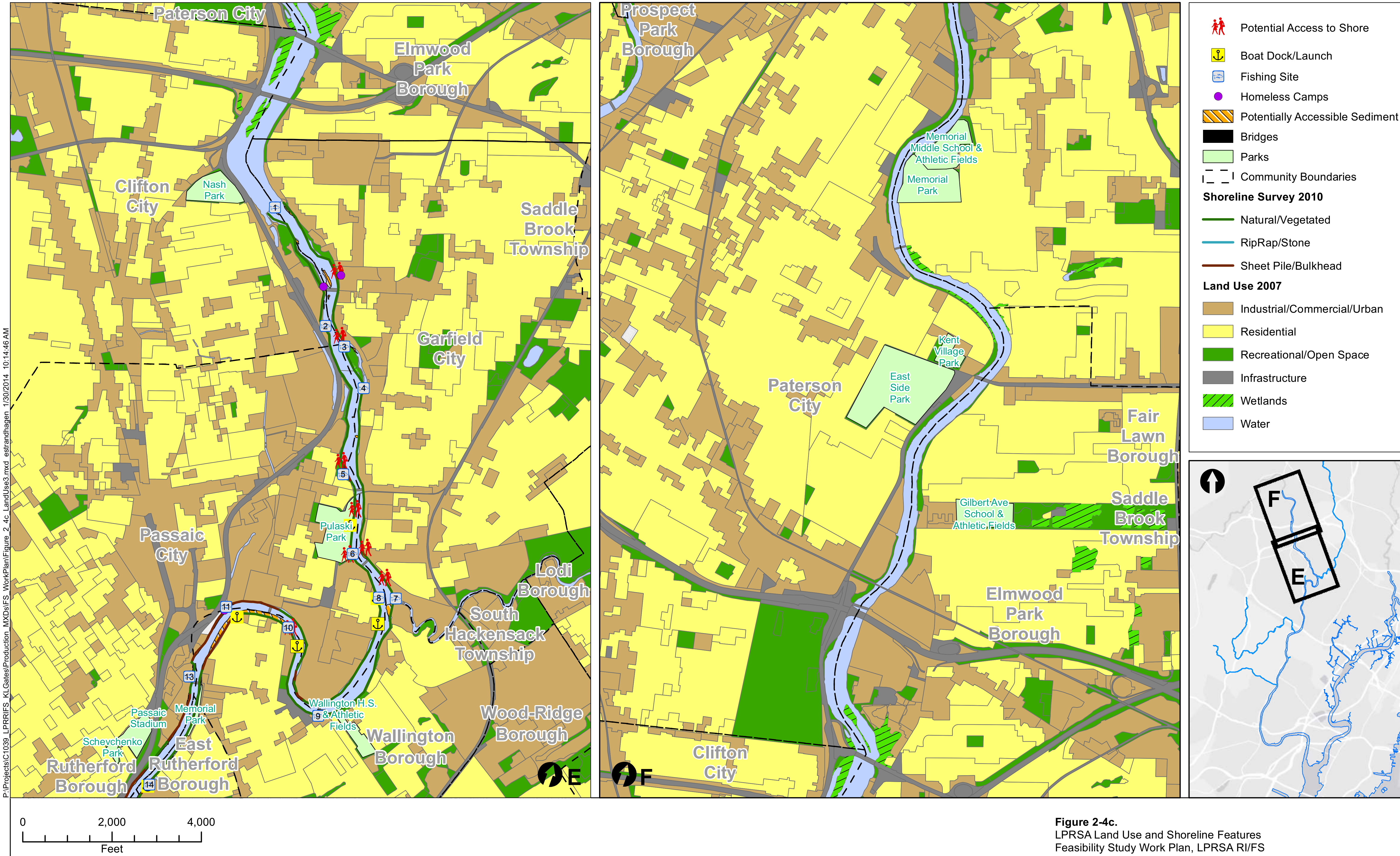

Figure 2-4c.
LPRSA Land Use and Shoreline Features
Feasibility Study Work Plan, LPRSA RI/FS

TABLES

Table 1-1. LPRSA 17-mile Remedial Investigation/Feasibility Study Data Sets

Type	Date	Location	Description	Number of Locations
Bathymetry				
CPG Periodic Bathymetry Surveys	September 2007	RM 0–14	Single and multibeam	100-ft single beam transect spacing
CPG Periodic Bathymetry Surveys	November 2008	RM 0–14	Single and multibeam	13 single beam transects
CPG Periodic Bathymetry Surveys	June 2010	RM 0–14	Single and multibeam	13 single beam transects
CPG River Mile 10.9 Field Investigation	July 2011	RM 10.9	Single and multibeam	
CPG Periodic Bathymetry Surveys	October 2011	RM 0–14	Single and multibeam	13 single beam transects
CPG Periodic Bathymetry Surveys	October 2012	RM 0–14	Multibeam, single beam in selected shoals	13 single beam transects and 9 shoal areas
Sediments				
MPI/Earth Tech – 2004 Sediment Coring for Dredging Pilot Project	July 2004	RM 2.6–3.1; cores from RM 2.9	Cores	15
MPI – 2005 Geotechnical Sediment Cores	May 2005	RM 0–16 (3 cores per transect every mile)	Cores	51
MPI – 2005 Surface Sediment Grab Sampling Program	August/September 2005	RM 1–17.4 plus Dundee Lake	Grabs	34
MPI – 2005 High-Resolution Sediment Coring Program	September/October 2005	RM 1.05–12.6 (for 5 cores with most analyses)	Cores	14
MPI – 2006 Low-Resolution Sediment Coring Program	January 2006	RM 2.9–6.7	Cores	10
MPI – 2007 Dundee Lake High-Resolution Coring Program	January 2007	Dundee Lake	Cores	4
MPI – 2007 – 2008 Supplemental Coring Program	December 2007 to January 2008	RM 1–12.6 and Dundee Lake (for surface grabs); RM 8.4–14.47 (for cores)	Cores and grabs	32

Table 1-1. LPRSA 17-mile Remedial Investigation/Feasibility Study Data Sets

Type	Date	Location	Description	Number of Locations
MPI – 2008 RM 0 to RM 1 Surface Sediment Sampling	June 2008	RM 0–1	Grabs	18
CPG Low-Resolution Coring (LRC) Program	2008	RM 0–17, Tribs, Dundee Lake	Cores and grabs	109
CPG Benthic Sediment Sampling	2009/10	RM 0–17	Grabs	132
CPG LRC Supplemental Sampling Program (SSP)	2011	RM 0–13.2, Dundee Lake	Cores and grabs	85
CPG River Mile 10.9 Field Investigation	2011	RM 10.9	Cores and grabs	60
CPG LRC SSP2	2012	RM 7–14.6	Cores and grabs	76
Surface Water				
CPG Physical Water Column Monitoring Program	2009/10	RM 0–13.2, Dundee Lake	Moorings, transect surveys	6
CPG Chemical Water Column Monitoring Program	2011–2013	RM 0–13.2, Dundee Lake	5 routine events 2 high flow events 1 low flow event 2 high volume events	6
Ecological/Tissue Sampling				
CPG Tissue Sampling Program		RM 0–17.4	117 blue crab; 281 fish tissue; 19 worm; 10 egg tissue; 10 mussel tissue; 166 animal tissue samples for benthic community assessment	
CPG Sediment Toxicity Sampling	2009/2010	RM 0–17.4		98
CPG Avian and Habitat Surveys	2010/2011			

Table 1-1. LPRSA 17-mile Remedial Investigation/Feasibility Study Data Sets

Type	Date	Location	Description	Number of Locations
Geophysical				
Aqua Surveys Inc. Geophysical Survey	2005	RM 0–16	Side-scan sonar survey, subbottom profiling, magnetometer, shallow pushcores (grain size and TOC), and deep cores (grain size, TOC, Atterberg limits, bulk density, moisture content and percent solids.	NA
Treatability Studies				
EPA Sediment Washing Demonstration Testing (BioGenesis)	2006/2007		Untreated and treated sediments, wastewater sludge	
EPA Cement-Lock Pilot Test (Endesco Clean Harbors)	2006/2007		Input and product sediments	
CPG River Mile 10.9 Sediment Washing Bench Scale Testing	2012	RM 10.9	Untreated and treated composite bulk sediment samples and wash water	5

Notes:

CARP = Contamination Assessment and Reduction Project
CPG = Cooperating Parties Group
EMAP = Environmental Monitoring and Assessment Program
MPI = Malcolm Pirnie, Inc.
NA = not applicable
REMAP = Regional Environmental Monitoring and Assessment Program
RM = river mile
TOC = total organic carbon

Data available at www.ourpassaic.org

Table 2-1. Peak Daily Average Flows at Little Falls

Recurrence Interval (years)	Discharge at Little Falls (cubic feet per second)
2	7,100
5	10,500
10	13,000
25	16,000
50	19,000
100	22,000
200	25,000
500	29,000

from Moffatt & Nichol [in-prep]

Table 2-2. Shoreline Land Use along the Lower Passaic River (%)

Land Use	RM 0–7	RM 7–17.4
Agriculture	0	0.6
Industrial/Commercial/Urban	72.6	32.4
Infrastructure	16.4	22.4
Recreational/Open Space	10.6	33.8
Residential	0.4	10.2
Wetlands	0	0.6

Notes:
RM = river mile
from AECOM [in prep]-e

Table 2-3. RI QAPPs and Data Characterization Reports

QAPP			Data Report				
Document Title	Submittal Date	Reference	Document Title	Original Submittal Date	EPA comments received	Approval/Final Submittal Date	Reference [a]
Quality Assurance Project Plan, RI Low Resolution Coring/Sediment Sampling, Lower Passaic River Restoration Project RI/FS, Rev. 4	October 2008	ENSR (2008)	Revised Low Resolution Coring Report	July 26, 2011			AECOM (2011b)
Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey	August 6, 2009	Windward (2009a)	Fish and Decapod Field Report for the Late Summer/Early Fall 2009 Field Effort			September 14, 2010	Windward (2010c)
			2009 Fish and Blue Crab Tissue Chemistry Data Report for the Lower Passaic River Study Area	September 19, 2011	January 10, 2014		Windward ([in prep]-c)
Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing	October 8, 2009	Windward (2009b)	Fall 2009 Benthic Invertebrate Community Survey and Benthic Field Data Collection for the Lower Passaic River Study Area	April 12, 2013		January 6, 2014	Windward (2014a)
			Fall 2009 Sediment Toxicity Test Data for the Lower Passaic River Study Area	January 31, 2012			Windward ([in prep]-l)
			2009 and 2010 Sediment Chemistry Data for the Lower Passaic River Study Area	September 2, 2011			Windward ([in prep]-a)
			2009 Bioaccumulation Tissue Chemistry Data for the Lower Passaic River Study Area	September 19, 2011			Windward ([in prep]-b)
Winter 2010 Fish Community Survey Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum No. 1	January 25, 2010	Windward (2010h)	Fish Community Survey and Tissue Collection Data Report for the Lower Passaic River Study Area 2010 Field Efforts			July 20, 2011	Windward (2011c)
Late Spring/Early Summer 2010 Fish Community Survey. Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum No. 3	June 22, 2010	Windward (2010e)					
Quality Assurance Project Plan/Field Sampling Plan Addendum, Remedial Investigation Water Column Monitoring/Physical Data Collection for the Lower Passaic River, Newark Bay, and Wet Weather Monitoring, Rev. 4	March 2010	AECOM (2010b)	2009/2010 Physical water column monitoring sampling program characterization report	March 31, 2014			AECOM ([in prep]-d)
Quality Assurance Project Plan, Lower Passaic River Restoration Project, Periodic Bathymetric Surveys, Rev. 2	May 2010	AECOM (2010a)	Periodic Bathymetry Survey Report, 2007 Multibeam and Single Beam Bathymetry Survey Report	October 30, 2007			GBA (2007a, b)
			Periodic Bathymetry Survey Report, 2008 Multibeam Bathymetry Survey Report	In prep			GBA (2008)
			Periodic Bathymetry Survey Report, 2010 Multibeam Bathymetry Survey Report	October 20, 2011			AECOM (2011c)
			Periodic Bathymetry Survey Report, 2011 Multibeam Bathymetry Survey Report	April 2, 2013	January 6, 2014		AECOM (2013c)
			Periodic Bathymetry Survey Report, 2012 Multibeam Bathymetry Survey Report	April 2, 2013	January 6, 2014		AECOM (2013d)

Table 2-3. RI QAPPs and Data Characterization Reports

QAPP			Data Report				
Document Title	Submittal Date	Reference	Document Title	Original Submittal Date	EPA comments received	Approval/Final Submittal Date	Reference [a]
Spring and Summer 2010 Benthic Invertebrate Community Surveys Addendum to the Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing. Addendum No. 1	May 17, 2010	Windward (2010g)	Spring and Summer 2010 Benthic Invertebrate Community Survey Data for the Lower Passaic River Study Area	January 31, 2012	January 14, 2014	January 22, 2014	Windward (2014c)
Late Spring/Early Summer 2010 Fish Tissue Collection Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum 4	June 21, 2010	Windward (2010f)	2010 Small Forage Fish Tissue Chemistry Data for the Lower Passaic River Study Area	July 18, 2012	January 14, 2014		Windward ([in prep]-d)
Avian Community Survey Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum No. 2	August 9, 2010	Windward (2010a)	Avian Community Survey Data Report for the Lower Passaic River Study Area Summer and Fall 2010			August 8, 2011	Windward (2011a)
			Avian Community Survey Data Report for the Lower Passaic River Study Area Winter and Spring 2011	July 17, 2012			Windward ([in prep]-i)
Collection of Surface Sediment Samples Co-Located with Small Forage Fish Tissue Samples Addendum to the Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing. Addendum No. 1	August 13, 2010	Windward (2010b)	2009 and 2010 Sediment Chemistry Data for the Lower Passaic River Study Area	September 2, 2011			Windward ([in prep]-a)
Habitat Identification Survey Addendum to the Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing. Addendum No. 3	September 13, 2010	Windward (2010d)	Habitat Identification Survey Data Report for the Lower Passaic River Study Area Fall 2010 Field Effort	April 12, 2013		January 6, 2014	(Windward 2014b)
Caged Bivalve Study Addendum to the Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing. Addendum No. 4	March 2, 2011	Windward (2011b)	2011 Caged Bivalve Study Data for the Lower Passaic river Study Area	July 18, 2012			Windward ([in prep]-e)
Quality Assurance Project Plan, Lower Passaic River Restoration Project, Low Resolution Coring Supplemental Sampling Program, Rev. 3	June 2012	AECOM (2012a)	Low Resolution Coring Supplemental Sampling Program Characterization Summary	December 30, 2013			AECOM (2013b)
Quality Assurance Project Plan, Lower Passaic River Restoration Project, Quality Assurance Project Plan/Field Sampling Plan Addendum, RI Water Column Monitoring/Small Volume Chemical Data Collection, Rev. 3	July 2012	AECOM (2011a)	Small Volume Chemical Water Column Monitoring Sampling Program Characterization Report	n/a			AECOM ([in-prep]-a)
Summer and Fall 2012 Dissolved Oxygen Monitoring Program Addendum to the Quality assurance Project Plan: RI Water Column Monitoring/Physical Data Collection for the Lower Passaic River, Newark Bay, and Wet Weather Monitoring	August 6, 2012	Windward (2012c)	Dissolved Oxygen Monitoring Program Data Report for the Lower Passaic River Study Area: Summer and Fall 2012	September 3, 2013			Windward ([in prep]-k)
Quality Assurance Project Plan, Lower Passaic River Restoration Project, Low Resolution Coring Supplemental Sampling Program Addendum, Second Supplemental Sampling Program, Rev. 1	September 21, 2013	AECOM (2013a)	SSP2 Data Report	n/a			AECOM ([in-prep]-c)
Background Tissue Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum No. 5	October 10, 2012	Windward (2012b)	2012 Fish Tissue Survey and Chemistry Background Data for the Lower Passaic River Study Area	n/a			n/a

Table 2-3. RI QAPPs and Data Characterization Reports

QAPP			Data Report				
Document Title	Submittal Date	Reference	Document Title	Original Submittal Date	EPA comments received	Approval/Final Submittal Date	Reference [a]
Background and Reference Conditions Addendum to the Quality Assurance Project Plan: Surface Sediment Chemical Analyses and Benthic Invertebrate Toxicity and Bioaccumulation Testing. Addendum No. 5	October 26, 2012	Windward (2012a)	2012 Benthic Invertebrate Community Reference Data for the Lower Passaic River Study Area	August 26, 2013			Windward ([in prep]-f)
			2012 Sediment Toxicity Reference Data for the Lower Passaic River Study Area	October 22, 2013	January 14, 2014		Windward ([in prep]-h)
			2012 Sediment Chemistry Background Data for the Lower Passaic River Study Area	October 30, 2013			Windward ([in prep]-g)
Quality Assurance Project Plan, Lower Passaic River Restoration Project, RI Water Column Monitoring/High Volume Chemical Data Collection, Rev. 2	December 2012	AECOM (2012b)	High Volume Chemical Water Column Monitoring Sampling Program Characterization Report	February 26, 2014			AECOM ([in-prep]-b)
Carp Harvest Pilot Study Addendum to the Quality Assurance Project Plan: Fish and Decapod Crustacean Tissue Collection for Chemical Analysis and Fish Community Survey. Addendum No. 6	September 11, 2013	Windward ([in prep]-j)	n/a	n/a			n/a

Notes:
FS = feasibility study
PWCM = physical water column monitoring
QAPP = quality assurance project plan
RI = remedial investigation
SSP = supplemental sampling program

[a] Documents previously submitted and currently in preparation are in revision in response to EPA comments.